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7.

MEMOIRS

OF THE

GEOLOGICAL SURVEY

OF

GREAT BRITAIN

AND OF THE

MUSEUM OF PRACTICAL GEOLOGY.

OXFORD

THE GEOLOGY OF

PARTS OF MIDDLESEX, HERTFORDSHIRE, BUCKINGHAMSHIRE, BERKSHIRE, AND SURREY.

(Sheet 7 of the Map of the Geological Survey of Great Britain.)

BY

WILLIAM WHITAKER, B.A. (Lond.), F.G.S.

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THE GEOLOGY

OF PARTS OF

MIDDLESEX, HERTFORDSHIRE, BUCKINGHAMSHIRE, BERKSHIRE, AND SURREY.

(SHEET 7 OF THE MAP OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.)

CHAPTER I.

INTRODUCTION.

WHILST writing this Memoir I have consulted all published accounts of the district that I could find, and have often quoted them, as may be seen by the foot-notes. I am specially indebted to the many papers of Mr. Prestwich, without studying which, indeed, it would be presumptuous in anyone to write on the geology of any part of the London Tertiary District. I have also used the note-books of my former colleagues Mr. T. R. Polwhele and the late Mr. R. Trench,* both of whom mapped parts of the district.

Sheet 7 of the Geological Survey Map represents an area of about 820 square miles, comprising, on the north of the Thames, a very small part of Oxfordshire, a large part of Buckinghamshire (with the towns of Amersham, Beaconsfield, Chesham, Colnbrook, Great Marlow, High Wycombe, Prince's Risborough, and Wendover), part of Hertfordshire (Barnet, Berkhampstead, Hemel Hempstead, Rickmansworth, St. Alban's, Watford, and part of Hatfield), and nearly the whole of Middlesex (Brentford, Staines, Uxbridge, and great part of London); and on the south of the Thames, a small part of Berkshire (Maidenhead and Windsor), and of Surrey (Richmond and a great deal of the southern part of London).

The *Thames* runs through this tract from west to east—with the exception of that part between Staines and Teddington, where the river makes a southern bend into the district to the south (Sheet 8).

The following streams flow into the Thames from the north :—At Cookham the *Loudwater*, rising from the Chalk at West Wycombe ; at Staines the *Colne*, which rises from the Chalk N.W. of North Mims, and receives the drainage of the Tertiary district north of Pinner and Elstree. {The following chalk-streams are tributaries of the Colne :—The *Misbourn*, rising at Great Missenden and joining the Colne west of Rickmansworth ; the *Chess*, rising at Chesham and joining at Rickmansworth; the *Gade* and the *Bulbourne*, which rising respectively at Northchurch and Little Gaddesden (in Sheet 46), unite at Two Waters, south of Hemel Hempstead, and flow into the Colne just east of Rickmansworth; and the *Ver*, which rises at Merkyate Street (Sheet 46) and joins the Colne at Colney Street, south of St. Alban's; whilst at Drayton the Colne receives the stream that rises from the inliers of the Reading Beds at Ruislip Wood and Pinner}; at Isleworth, the *Yedding* Brook, the result of the drainage of the London Clay district between Uxbridge and Harrow; and at Brentford the *Brent*, the result of the drainage from the same formation between Harrow, Barnet, and Hampstead, and of the springs on the north-western side of the outlier of Bagshot Sand at the last place. The springs from the inliers of the Chalk and the Reading Beds at Northaw, and the drainage of the London Clay of Totteridge and Finchley, fall into the Lea (Sheet 1), which flows into the Thames at Blackwall.

---

* I shall be much obliged by anyone who will let me know of any new sections in the district (or in that to the east or south), whether open cuttings or wells, or of any old ones that have escaped my notice.

The Table of Well-sections given in Appendix 2, will, I trust, be carried on in the Memoir that will be written to accompany Sheet 1 of the Geological Survey Map, which contains the eastern part of London.

On the south the Thames is joined in this district by fewer streams:—At Twyford the *Loddon*, which rises from the Chalk near Basingstoke (Sheet 12), and receives the drainage of a large Tertiary district; at Putney the brook that results from the drainage and gravel-springs of the eastern side of Richmond Park, of the western side of Putney Heath and Wimbledon Common, and of the clay-country to the south (Sheet 8); and at Wandsworth the *Wandle*, which rises from the Chalk and Lower Tertiary beds at Croydon (Sheet 8).

The Geological Formations that come to the surface in this district are:—

POST-PLIOCENE.	ALLUVIUM. VALLEY BRICK-EARTH AND GRAVEL. *Clay-with-flints* (a deposit confined to the chalk-country). *High-level Brick-earth and Gravel.* *Boulder Clay.*
	TERTIARY.
MIDDLE EOCENE.	LOWER BAGSHOT BEDS.
LOWER EOCENE.	LONDON CLAY. WOOLWICH AND READING BEDS.
	SECONDARY.
UPPER CRETACEOUS	CHALK. UPPER GREENSAND. GAULT.

Those deposits, the names of which are printed in italics, are not shown on the map by colour; neither is the whole of the valley-gravel, for reasons that will be given further on (p. 73).

There are two formations, the Lower Greensand and the Thanet Sand, which, not coming to the surface in this district, are not shown on the map, but they have been found in well-sinking, and a short account of each will therefore be given.

The general trend of the different formations is nearly S.W. and N.E., those belonging to the Cretaceous series taking up rather less, and those of Tertiary age rather more than half of the district. The former occur on the north and west, the latter on the south and east; while the various post-tertiary beds lie irregularly on both. The general dip is about S.E. at a very small angle.

An account of the range and character of each formation will now be given, beginning with the lowest and oldest, and working from the west eastwards.

Any section that shows more than one formation will be described at length the first time that it has to be mentioned, as it would clearly be awkward to give part at one place and the rest at another.

The reader, having been made acquainted with the nature of the beds, will be ready to understand the effect which each will have on the "form of the ground," which subject will then be treated of.

CHAPTER II.—CRETACEOUS SERIES.

LOWER GREENSAND.

This formation does not crop out to the surface in the district under notice, but it seems likely that some of the lowermost beds found in the deep well-boring at Kentish Town may belong to it. I take the following list of the formations passed through from the full account of this section given by Mr. Prestwich.*

	ft.
London Clay - - - - - -	236
Woolwich and Reading Beds - - - -	61½
Thanet Sand - - - - - - -	27
Chalk - - - - - - -	586
Upper Greensand - - - - - -	72½
Gault - - - - - - -	130½
Alternations of sands, sandstones, and clays, mostly red (partly Lower Greensand?) - - - -	188½
	1302

There is, however, great doubt to what formation these lowest beds may belong. To quote Mr. Prestwich, "Do these red beds form an "exceptional condition of the base of the Gault? Are they local "beds of the Lower Greensand? Do they belong to the mottled clays "and sandstones of the Wealden? Or are they to be placed with the "New Red Sandstone?" (See also Appendix 3, p. 106.)

GAULT.

This stiff blue clay takes up a triangular space of about seven square miles at the north-western corner of the district. With the exception of ditches, &c., there are no sections of this the lowest outcropping formation, but its presence is unmistakably shown by the damp nature of the land; and, owing to the very slight dip (to the south-east), the Gault country is of considerable breadth. I have no data for calculating the thickness of the Gault here, but should think that it may be over 200 feet (see fig. 15, p. 96).

In his account of the Kentish Town well, Mr. Prestwich says that the Gault "presented the ordinary character of a fine grey calcareous "clay, 130½ feet thick. At the base of this mass of clay a layer full "of the phosphatic nodules so common at the base of the Gault at "Folkestone and elsewhere was met with."†

UPPER GREENSAND.

This formation overlies the Gault, with a S.W. and N.E. strike, from Henton, at the western edge of the map, to near Bushey Leys, on the northern edge, and forms at the surface a band of from half a mile to a mile in breadth, being soon covered in its turn by the Chalk. The junction with the Gault is for the most part marked by a rise of the ground (see fig. 15, p. 96), a change from a clayey to a more sandy soil, and by springs.

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* Journ. Geol. Soc. vol. xii. p. 6.

† Journ. Geol. Soc. vol. xii. p. 8.

In this district the Upper Greensand consists almost wholly of a soft whitish crumbling sandstone, sometimes calcareous, here and there hard; the upper bed of greensand being here but sparely developed. This latter thickens westward, and takes up a considerable space.*

The lower and harder beds may be seen along the Lower Icknield Way south of Henton, at Bledlow Cross, between that place and Bledlow, on the road just N.W. of Horsendon, near Park Mill, along the small stream running from Allscot to Longwick Mill, "beneath the Lower Icknield Way, at Chadwell Hill,"† at Meadle, just S. of Kimblewick Farm, a quarter of a mile S.W. of Thorpes, and near Little Kimble church. None of the sections are deep, most being merely road-cuttings: indistinct fossils occur in many places.

Of the dark rather clayey green sand that in this district and to the west forms the upper bed of this formation, I saw but three small patches. One of these is at the western edge of the map, near the southern end of Henton and some distance from the junction with the Chalk, another is at that junction about a third of a mile from the edge of the sheet; and the third is nearly half a mile west of Little Kimble church, and about a quarter of a mile from the Chalk, the green clayey sand being shown along the road, and along the brook grey sand with crumbling sandstone. No fossils have been found in this upper bed.

In his paper on the Kentish Town well-section, Mr. Prestwich classes with this formation 58 feet 9 inches of "bluish-grey marl, rather sandy," and 13 feet 9 inches of "dark green sand mixed with grey clay," and says that "the chalk-marl passes so insensibly into slightly sandy marls "representing the Upper Greensand, and these into the Gault, that it "is difficult to draw any satisfactory lines of division."‡

CHALK.

This well known soft limestone, which is at the surface over a very large part of our district, may here be treated of under three heads: the "Lower Chalk," the "Chalk-rock," and the "Upper Chalk."

Professor Ansted observes that "the bottom beds of the chalk are "usually of somewhat lower specific gravity than the upper. . . . The "upper chalk may be regarded as most usually the conducting, and the "lower chalk as the containing, part of the formation, so far as water "is concerned."§

LOWER CHALK.

This is the thickest of these divisions, being most likely 400 or 500 feet thick at its outcrop, and it not only rises from above the Upper Greensand to within a small distance from the top of the high chalk-escarpment (see fig. 15. p. 96), but also runs along the main chalk-valleys to a distance of many miles from the escarpment. Its line of junction with the Upper

---

* See Geological Survey Memoir, illustrating Sheet 13, p. 18.
† Dr. Fitton, in Trans. Geol. Soc. 2d ser. vol. iv. p. 271.
‡ Journ. Geol. Soc. vol. xii. pp. 13 and 8.
§ Proc. Inst. Civ. Eng. vol. ix. p. 361.

Greensand follows that of the latter and the Gault from a point between Henton and the Upper Icknield Way to a little beyond Chalkshire. The line of springs along this junction has determined the site of the many villages (Bledlow, Saunderton, Prince's and Monk's Risborough, Ascott, Great and Little Kimble, and Chalkshire) that here, as in the country to the west (Sheet 13), occur at or near the outcrop of the Upper Greensand.

The Lower Chalk in this district does not contain those beds of flint-nodules that are so common in the higher division. The lowest beds are sometimes very hard, as between Bledlow and Saunderton. At Butler's Cross, west of Wendover, there is a pit showing grey chalk, irregularly bedded, capable of being quarried in large blocks. About eight or 10 feet from the bottom there is a line of cream-coloured nodules, like those in the "chalk-rock" (hereafter to be described), which bed, however, must be much higher up than this pit. I know of no section in this district that has yielded any number of fossils.

The extent to which the Lower Chalk runs along the valleys that are cut through the great escarpment is known by the occurrence of the bed next to be treated of.

CHALK-ROCK.

The bed to which I have given this name * is a hard cream-coloured chalk with lines of irregularly shaped green-coated nodules. Where well-developed it is jointed at right angles to the plane of bedding and is quarried in large blocks. In this district it is, for the most part, not so well marked as in the country to the west,† where it is seen to be the topmost bed of the Lower Chalk; there being no flints either in or below it, whilst a bed of them often rests on it, and its upper surface being more sharply marked than the lower.

The chalk-rock may be seen on the flank of the great escarpment a mile S.W. of Bledlow. It seems to have been disturbed, and is capped by reconstructed chalk containing fragments of the "rock" itself.

The best sections are in the valley of the Thames between Henley and Marlow. In a chalk-pit above Greenland Lodge, near the western edge of the sheet, it is about four feet thick and is overlain by rubbly chalk; but being at a great height above the bottom of the pit it cannot be got at: the chalk below is without flints, with the exception of two seams, not a quarter of an inch thick, that fill highly inclined fissures proceeding from a small fault, and which have clearly been deposited in those fissures from a siliceous solution flowing through them. In another pit, by the side of the high road a third of a mile west of Medmenham, there is a very good section, showing :—

Chalk with a few flints.
Line of flints.
Chalk-rock, much and evenly jointed, about 4 feet.
Chalk without flints.

The "rock" is well marked by its cream-coloured tint, contrasting with the white of the chalk both above and below; it is sharply

---

* In the 2nd edition of the "Catalogue of Rock Specimens in the Museum of Practical Geology." For a general account of this bed, see Journ. Geol. Soc. vol. xvii. p. 166. There are specimens of the rock in the Museum, see 3rd edit. of the catalogue, p. 160. I have traced the Chalk-rock to a little eastward of Luton, Beds. (May 1864).

† See Geological Survey Memoir on Sheet 13, p. 20.

divided from the former, but not from the latter, which is hard towards the top and passes into the rock.

The chalk-rock may be seen along the valley that runs into that of the Thames on the S. of Hambledon, by the road on the western flank of Pheasant's Hill.

The Lower Chalk thus shown to crop out between Medmenham and Henley is an "inlier," being surrounded on all sides by the Upper Chalk.

In the Loudwater Valley the chalk-rock may be seen just above Bottom Farm, at the northern end of the hill W. of Bradenham; and again, at the southern end of the same hill, above the village of West Wycombe. It occurs in a chalk-pit on the hill-flank just outside of High Wycombe, on the N.W.; and in another west of Upper Marsh Hill, S.E. of the same town, where it is more than five feet thick, but less compact and jointed than in the country to the west, and has a bed of flints resting at once on it. The railway-cutting S.W. of Wycombe Marsh is in the Lower Chalk, without flints; at the top, and for a short distance along the road to the south, the chalk-rock is shown: it is irregular in structure and not hard throughout, beds of hard cream-coloured rock with nodules alternating in fact with beds of chalk: there is full seven feet between the top and bottom beds of the rock, which is not jointed but breaks up into small pieces: higher up the road the Chalk-with-flints comes on. The chalk-rock, overlain by the Chalk-with-flints, may again be seen in the cutting on the road that crosses the railway a little S.E. of the above. It probably crops out for some way up the Hitchendon Valley, which joins that of the Loudwater at Wycombe.

In the Misbourn Valley this bed may be seen along the road up the hill east of the Hale near Wendover, and along that up Jenkins Hill (to King's Ash) S.E. of the same town: there are here two bands of the rock, about 12 feet apart; the Chalk-without-flints occurs below, and that with flints above. I was told that in Buckland Wood, west of this, the chalk-rock had been found at a depth of about 50 feet. It was to be seen, in 1859, by the road a little above Great Missenden church; and at the brick-yard at Hyde Heath, about a mile and a half to the east, two beds of the rock have been found in sinking for chalk. It crops out as far south as Amersham, and may be seen on the road up the hill north of the town, and on the turnpike-road just east of the mill at its eastern outskirts. In sinking for chalk in parts of Penn Wood, between Amersham and High Wycombe, the chalk-rock has been found at a depth of from 40 to 50 feet, but has not been sunk through, by reason of its hardness.

In the Chess Valley it is shown in three road-cuttings near Chesham —up White Hill, up the hill to the west on the other side of the town, and just above Lower Germans — and close by Elliott's mill, rather more than two miles S.E. of the town.

In the Berkhampstead or Bulbourne Valley the chalk-rock may be seen on the road up the hill S.S.W. of Berkhampstead church. In a chalk-pit on the southern side of the railway, a short distance eastward from Boxmoor station, it is seen to be little more than a foot and a half thick, the uppermost three inches being almost wholly made up of the nodules; there are here a few flints below it, and above it is rubbly reconstructed chalk (partly of pieces of the "rock" itself). It again occurs in the railway-cutting N.W. of Apsley, and it has been found about 50 feet below the surface of the ground at the limekiln about a quarter of a mile N.N.E. of Nash Mill.

I have not seen any section of the chalk-rock along the Hemel Hempstead or Gade Valley, which joins that of the Bulbourne at Two

Waters; but I should think that it crops out along that valley. Mr. J. Evans, F.G.S., of Nash Mills, tells me that there is a second and lower bed of rock in this neighbourhood. In the country to the north (Sheet 46, S.W.) I have seen three beds.

In the third edition of the "Report to the Directors of the London "(Watford) Spring-water Company," by Mr. S. C. Homersham, Mr. R. Paten makes the following statement: "In boring through the chalk in "the valley of the Colne various beds of hard chalk-like rock are "encountered; these vary in thickness from 12 inches to 8 feet, and "below them are found large fissures or cavities from 12 inches to "12 feet in depth, strongly charged with water." It is therefore possible that the chalk-rock may have been split up into many beds; or that other like beds may have come on above or below.

The section of the experimental well in Bushey Meadows is as follows, the measurements being made from the engraved section given in the report:

Clay - - - - -	nearly 2 feet	25 feet.
Gravel - - - - -	about 21 ,,	
Black peat (?) - - - -	,, 2 ,,	
Chalk, with five beds of flints - -	,, 21 ,,	125 ,,
,, without flints, but with many hollows (11 drawn) full of water -	,, 104 ,,	

The Rev. J. C. Clutterbuck, who has long studied the water-supply of the Chalk, says that "he must be permitted to record his doubts as "to the existence of those fissures at the bottom."*

Although so thin the chalk-rock has here yielded many fossils, as may be seen by the following list, which shows that this bed forms a part of the Lower rather than of the Upper Chalk.

FOSSILS from the CHALK-ROCK.

Baculites.
Nautilus.
Rhyncholite (*of Nautilus*).
**Scaphites æqualis*, Sby.
Turrilites.

**Solarium?*
Trochus?
Turbo?
**Turritella?*

**Anomia?*
Inoceramus.
Pachymya?
Spondylus latus, Sby.

S. spinosus, Sby.

Rhynchonella Mantelliana, Sby.
Terebratula biplicata, Sby.
**T. carnea*, Sby.
T. semiglobosa, Sby.

**Bryzoon.*

**Serpula.*

**Cidaris.*
**Micraster.*

Parasmilia.

**Ocellaria.*
Ventriculites.

The above list is the one given in my paper,† with the addition of 10 fossils, the names of which are marked with an asterisk, found since the publication of that list, by Mr. Evans and myself at the Boxmoor chalk-pit, and at the lime-kiln near Nash Mills; it is almost wholly due to the observations of Mr. Evans, and the species were mostly determined by my colleague Mr. Etheridge.

In the river-cliff on the right bank of the Thames, about a mile S.E. of Great Marlow, a large pit shows about 50 feet of chalk, all of which is rather hard. There are marly beds but no flints, which leads one to think that it may be Lower Chalk. If this be the case there must be some disturbance. The inference that the Lower Chalk is here present is strengthened by the section in the road-cutting up Winter Hill, a short distance N.E. of the pit, which shows a little way above the river, some very hard rubbly chalk, that might be chalk-rock, and Chalk-with-flints above.

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* Proc. Inst. Civ. Eng. vol. ix. p. 163.
† Journ. Geol. Soc. vol. xvii. p. 167.

Upper Chalk.

In the district under notice this division of the Chalk is marked by the frequent occurrence of flint in some of the lines of bedding, mostly in the form of irregular-shaped nodules, but sometimes as a continuous bed, which latter condition may be seen in a chalk-pit at Cookham Dean, about a mile and a-half N.E. of Great Marlow.

In a pit on the south of Hurley, also near Marlow, there is in the Chalk-with-flints a somewhat irregular bed of hard cream-coloured chalk, a few inches thick.

The Upper Chalk takes up a great part of the district, spreading from the top of the escarpment as far south as Twyford, and as far east as Hatfield, and, speaking roughly, forming nearly the whole of the country from the escarpment to a line joining those places. The Lower Chalk, however, as before noticed, crops out for a long distance down the main valleys, and there are many outliers of the Lower Tertiary beds covering the Upper Chalk (see p. 31). There are two small "inliers" of this division at Windsor and Northaw (see pp. 27, 30). The former, however, perhaps may not be an inlier. Mr. Prestwich says of it—"Windsor Castle stands upon chalk, although apparently "in the midst of a Tertiary district."[*]

Although this division takes up a larger surface than the Lower Chalk, yet it is not so thick, its thickness in this district most likely being nowhere more than 300 feet, if even so great.

The higher beds of the Chalk do not occur at the great escarpment, where indeed only the lower part of the Upper Chalk is present; but they come on gradually to the S.E., for although the slope of the country is in that direction the dip of the beds is so also, and is at a slightly greater angle than the slope; so that in going from the escarpment to a lower surface-level south-eastwards one also rises to higher geological levels. This may be more readily understood by looking at fig. 15, p. 96.

The Upper Chalk is distinguished moreover from the Lower by its fossils; for whilst the latter generally yields species of whorled and spiral Cephalopods (*Ammonites*, *Turrilites*), the former is chiefly characterized by many species of Echinoderms (of the genera *Ananchytes*, *Cidaris*, *Galerites*, and *Micraster*) and of Sponges and Ventriculites. The characteristic fossils of the Upper Chalk may generally be found in the pits, of which there are many. They occur in the flints as well as in the chalk itself. The following is, as far as I know, the only list that can be got for this district; it is of those in the collection of the late Mr. Sheldon Wilkinson of Great Marlow. They were all found at that place, and many are very fine specimens:—

Fish remains.

Inoceramus.
Lima?
Spondylus spinosus.

Rhynchonella.
Terebratula carnea.
T. sp.?

Ananchytes ovatus.
Cidaris.
Galerites.
Micraster coranguinum.

Coral.

Ventriculites.

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[*] "Water-bearing Strata of the Country around London" (Van Voorst, 1851) p. 41, foot-note.

Mr. Evans, of Nash Mills, has got many fossils from the Chalk near Boxmoor, besides those from the "Chalk-rock;" but most likely some are from the Lower and others from the Upper Chalk. Besides some of the above species Mr. Evans' collection contains:—*Lamna* tooth, ctenoid fish scales, fish palate, *Ostrea vesicularis*, *Pecten Beaveri*, and *Holostoma contingens*.

Reconstructed Chalk.

In a chalk-pit by Batten's Barn, a mile north of Burnham near Maidenhead, I saw, in August 1860, about 18 feet of reconstructed chalk, with scattered flints and blocks of chalk, and a line of flints near the middle. There were some pipes of the surface "clay-with-flints," so common in chalk countries (see p. 63) in the top part of this bed, which is like that noticed at Maidenhatch Farm and near Tilehurst, in the district to the west (Sheet 13),* at which latter place the reconstructed chalk was overlain by the bottom-bed of the Reading Beds; showing that the reconstruction took place before the deposition of the latter formation. The section at Batten's Barn is but a little way below the boundary-line of the Reading Beds. I have given a short account of these and other like sections in Journ. Geol. Soc. vol. xvii. p. 527.

CHAPTER III.

LOWER EOCENE SERIES.

THANET SAND.

This formation, the lowest of the English Tertiary beds, like the Lower Greensand does not crop out to the surface in this district, but it is found in making deep wells in and near London, and as it is a water-bearing bed is the more worthy of notice here. It consists of fine soft light-coloured sand, slightly clayey, more especially towards the base, where it has a greenish-grey tinge. At the base, and lying at once on the Chalk, is a layer of green-coated unworn flints, in a clayey greensand.

Under London and its southern suburbs the Thanet Sand is from 13 to 44 feet thick, according to the well-sections (see pp.102-5). Further westward it is thinner, "being only 20 feet thick at Wandsworth, 17 feet at Isleworth, seven feet at Twickenham."† At Ealing it has gone altogether, as there the Reading Beds rest at once on the Chalk; and the same is the case at The Hyde, on the Edgware Road (see p. 100). It does not occur further west; but to the east (in Kent and South Essex) it thickens‡ and takes up some space on the map. It may be well seen near Woolwich.

As this formation does not crop out in this district, the overlying one, the Woolwich and Reading Series of Mr. Prestwich, comes on at once above the Chalk.

WOOLWICH AND READING BEDS.

Structure.

Though of no great thickness, from 25 feet at the out-crop near Hatfield (p. 22) to 90 feet beneath the London Clay at Chiswick (p. 103), this formation is very changeful in composition. The "bottom-bed"* is towards the west a roughly laminated clay with green grains, green-coated flints, and here and there a little sand; whilst eastward the clay disappears and its place is taken by a light green sand, often crowded with flint-pebbles; and further in the same direction the green colour is lost. The rest of the formation consists of irregular alternations of sands (light and dark-coloured, coarse and fine) and plastic clays (of many and often very bright colours). In places a thin bed of sandstone may be found, and towards the east beds of black-flint pebbles in sand occur here and there. At one part there may be hardly anything but clay, at another sand prevails, and at another both occur in nearly equal quantity. In one thing the Woolwich and Reading Beds are alike all along their lengthy northern outcrop, namely, in not yielding fossils, excepting the oyster-shells that are sometimes so plentiful in the bottom-bed. At the south-eastern corner of the district, however, nearly all is changed; the mottled plastic clays have almost wholly gone, and we find alternations of sands, loams, and clays, with sometimes thin beds of clayey-limestone, sandstone, or shell-conglomerate, in great part containing shells which belonged to animals that must have lived in fresh or brackish water. In fact we have passed from the marine Reading Beds to the estuarine Woolwich Beds. As usual with deposits of the latter class the species of fossils are not very many, but the number of individuals of the common species is very large.

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* See Memoir illustrating that sheet, p. 21.

† Prestwich, Journ. Geol. Soc. vol. viii. p. 241.

‡ See Journ. Geol. Soc. vol. viii. p. 240, and vol. xviii. p. 263.

It is almost wholly through the observations of Mr. Prestwich that the parallelism of the widely differing members of this the old "Plastic Clay" Series has been clearly made out, indeed that all the beds between the London Clay and the Chalk have been reduced to order; and I would refer the reader to that gentleman's papers † for a general account of this and the other Lower Tertiary formations.

Range.

The Reading Beds ‡ come on above the Chalk along an irregular line from Twyford to Hatfield Park, but are generally soon capped in their turn by the London Clay; so that they form for the most part a narrow band, sometimes less than an eighth but sometimes more than three-quarters of a mile in breadth. On the south of Beaconsfield, however, they take up a broader space. At Dulwich, at the S.E. corner of the district, the Woolwich Beds crop out from below the London Clay. This small area is part of the northern outcrop, on the southern side of the Thames (in Sheet 1).

The wide-spreading Chalk is, moreover, capped in many places by outliers of this formation, on the larger of which there are also patches of London Clay. These outliers, though important in themselves, both economically and as proving the former extension of the Tertiary Beds, take up but a very small space compared with that over which the Chalk is free from those beds. They occur chiefly along a line from Wargrave, through Cookham Dean, Loudwater, a point between Amersham and Chalfont St. Giles, Sarratt and Abbot's Langley, to St. Albans.

Near Ruislip, and at Pinner and Northaw, all well within the boundary of the London Clay, there are inliers (see p. 27) of the Reading Beds, which formation in these cases has been raised up, by local disturbance, within reach of the denuding power that caused the present shape of the ground at those parts. The same must be the case at Windsor, if the Reading Beds on the south of the castle form an inlier, as is not unlikely.

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* A name given in the Memoir illustrating Sheet 13 of the Map of the Geological Survey, p. 23.

† Journ. Geol. Soc. vols. vi. viii. and x.

‡ It will often be convenient to use either of the names Woolwich or Reading alone.

Junction with the Chalk.

Although sections do not show any unconformity between this formation and the Chalk, there is but little doubt that there is some unconformity, so gradual that it can be inferred only by the comparison of a series of distant sections. However, although the Reading Beds may rest on different beds of the Chalk at different places, there are as yet no means of absolutely proving such to be the case in this district. That there are local irregularities in the junction of these formations is well known; but these are now held to be owing to causes that have come into action after the deposition of the Reading Beds. I refer of course to the "pipes" of these beds that are so common in the Chalk. The late Mr. Trimmer held to the belief that these hollows were worn out in the Chalk before the deposition of the next overlying formation,* but I think that all Tertiary geologists now agree with the views of Sir C. Lyell† and Mr. Prestwich,‡ and hold that the pipes are caused by the gradual and irregular dissolving away of the chalk by carbonated water that has filtered through the beds above, and the consequent falling in of the latter. I have elsewhere noticed the fact that "where the Chalk is more thinly covered, and therefore less pro- " tected from the chemical action of carbonated water, pipes are both " larger and more numerous,"§ which is further evidence in favour of the theory of the chemical origin of the pipes in the Chalk.

There are often "swallow-holes" at or near the junction of the Reading Beds with the Chalk in this district, as in the more westerly part of the London Basin, (sheets 12 & 13). "They are here formed " by streams which flow down the escarpment of the Tertiary beds, or " the slopes of outliers, until they reach the more pervious and jointed " Chalk, into which they sink, or until they come within a short " distance of that rock, when they work their way into it through the " few feet of the softer overlying beds. In the course of time, through " the chemical action of the carbonic acid in the water, and the " mechanical action of the water itself, funnel-shaped basins are worn " out in the Chalk and the beds above, the operation being made " more easy by any pre-existing fissures, often overgrown with vege- " tation. The streams may sometimes be seen running through them, " though sometimes they merely flow into a small pool, the level of " the water in which remains the same notwithstanding the constant " flow."‖ From the fact of these swallow-holes being near the junction of the Reading Beds and the Chalk, they often help one in drawing the boundary-line of the former. They sometimes occur, however, at a distance from the Tertiary beds, and sometimes well within their boundary; both these conditions may be seen in the Mims Valley (see p. 20).

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* Journ. Geol. Soc. vols. i. p. 300, x. p. 231, and xi. p. 62.

† Phil. Mag. 3d ser. vol. xv. p. 257.

‡ Journ. Geol. Soc. vol. xi. p. 64.

§ Memoir, illustrating Sheet 13 of the Map of the Geol. Survey, p. 25.

‖ Memoir, illustrating Sheet 13 of the Map of the Geol. Survey, p. 19.

The Chalk immediately underlying the Reading Beds has been in some places drilled to a depth of a foot or more by boring molluscs, and the network of tubular cavities thus formed is filled with the clayey greensand of the bottom-bed.

The boundary-line and the line of outcrop* of the Reading Beds are for the most part of a very winding character, owing to irregular denudation.

I will now give a detailed account of this formation, treating firstly of the main mass, then of the inliers, and lastly of the outliers.

MAIN MASS.

On the western side of the Loddon, which river joins the Thames at Twyford, the junction of the Reading Beds and the Chalk is hidden by gravel, but its position is approximately shown by a swallow-hole about a quarter of a mile S.W. of Chorvil Farm. The cutting on the Great Western Railway is now too much overgrown to show the beds.

On the other side of the Loddon these beds are again hidden by gravel, but in the railway-cutting east of Twyford Station variously coloured clays and sands are shown beneath the gravel. Clay seems to be more abundant at both ends of the cutting; sand in the middle part. At one place, near the middle of the cutting, there are some small pieces of hæmatitic ironstone.

N. and N.E. of Ruscomb the gravel ends off, and the Reading Beds are at the surface. At the brick-yard there is plastic clay, and the green clayey sand of the bottom-bed may be seen in the fields to the N.E. In the large pit west of the church I saw (in September 1860) under the gravel a few inches of plastic clay, with brown laminated sand below, seven feet of the last being shown. In a well at some cottages near by, on the other side of the railway, the Chalk was not reached at a depth of 40 feet, whilst in another close to the church that rock was touched at a depth of about 30 feet: in both cases clay was in excess.

At Stanlake, south of Ruscomb, in a well in the farm-yard close to the house, 23 feet of clay were found above white sand, the latter yielding plenty of water. At the highest part of the road between Stanlake and Hinton House there is plastic clay; and in the lane, about half a mile a little N. of E. of the latter place, sand is shown.

For more than a mile eastwards from Stanlake, towards St. Laurence Waltham, the boundary-line is hidden by the alluvium of what was once Ruscomb Lake (see p. 94), and then runs roughly parallel to the Great Western Railway by Shottesbrook and White Waltham to Shoppenhangers Farm, near Maidenhead.

There are no good sections of the Reading Beds in this tract of country; plastic clay occurs by the meeting of the roads more than half a mile S. W. of White Waltham church. "By the bridge at Paley "Street there is a stiff mottled clay with spots and streaks of pipe-clay "below the basement-bed of the London Clay (see p. 48); and in "the lane about 200 yards N. W. of Shoppenhangers Farm there is

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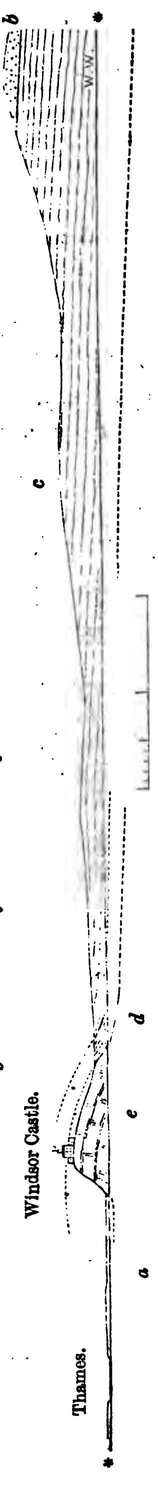
* By "boundary-line" is here meant that line along which any formation comes on over the formation next below, this being truly the line that bounds a formation, and beyond which it does not reach; in contrast with the "line of outcrop," which is only a boundary at the surface, as a formation spreads some way underneath the beds above.

Fig. 1.—Section from North of Windsor Castle to Spring Hill.



Horizontal Scale, 2 inches to a mile; Vertical Scale, four times as great (an inch = 660 feet).

(*a*) Gravel of the Thames. (*b*) Lower Bagshot Sand. (*c*) London Clay. (*d*) Reading Beds. (*e*) Chalk. (* *) Approximate sea-level.

"also mottled clay."* East of this the high terrace of the Thames gravel (see p. 84) hides the Reading Beds; but at the junction of the roads half a mile west of Bray Wick there is some plastic clay, and there are signs of the same being present, below the gravel, just west of the same place.

At Stud Green, on the south, "the pit in the "brick-yard gave the following section, ac-"cording to the workmen :—

Brick-clay, sandy - -	5 feet.
Bands of sandstone - -	1 foot.
Brick-clay - - - -	9 feet.
Plastic clay and blue clay.	

"The *Ditrupa plana* was found in the base-"ment-bed."* It is hard to say where is the division between the London Clay and the Reading Beds here, but I should think that only the first two beds belong to the basement-bed of the London Clay.

Eastward to Windsor the boundary-line is altogether hidden by the Valley-gravel, which on the east of Oakley Green spreads over to the London Clay, so that the line of outcrop of the Reading Beds is then hidden also.

At Windsor, however, it is most likely that this formation again crops out. The castle is on bare Chalk, whilst to the south the London Clay comes on, and although there is no section of the Reading Beds one naturally infers their presence. My colleague, Mr. Polwhele, who mapped the Windsor district, has indeed suggested that this hill may have been an island in the London Clay period, and therefore that the London Clay may have been here deposited against the Chalk, without any of the Reading Beds occurring between; but as I know of no instance of such a thing elsewhere, I think it would be safer to look on this chalk-area as the result of a much later disturbance, after the deposition of the London Clay, and to suppose that a section across it would be as in fig. 1.

The boundary-line of the Reading Beds is of course very doubtful, and it is possible that they may here occur as an inlier (see p. 27).

On the northern side of the Thames at and west of Windsor the gravel spreads farther from the river than on the southern side, and the line between the Chalk and the Reading Beds is therefore quite as doubtful.

"At Horse Harness, north of Burnham, "plastic clay may be seen in the ditch,"* and at Burnham Grove a thin strip of this formation, less than half a mile long, crops out from beneath the gravel that covers the hill. Along the valley to the east and south denudation has laid bare the Chalk for some distance, and on great part of its eastern side a little of the Reading Beds shows between the gravel and the Chalk. In a pit here—on the southern side of the road, less than a mile east of Burnham church—the following section was shown (1858) :—

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* From Mr. Polwhele's Note-book.

Brown flint-gravel, 10 feet or more.		
Reading Beds	Mottled plastic clay, brown blue and crimson	5 or 6 feet.
	Green sand, rather clayey (bottom-bed) - -	
Rubbly Chalk.		

At the junction of the gravel and the clay much water oozed out, and wore away the latter. In a pit less than a quarter of a mile to the north there is only gravel above the Chalk.

" I was told that in digging a shaft for getting chalk, a mile east of Burnham, 30 feet of gravel, 20 of plastic clay, and two of greensand were passed through in descending order." *

From this small valley the boundary-line runs N. W. to Hedsor, following the contour of the ground, and therefore winding up and down the hollows. From Hedsor it again takes its usual N. E. course; but soon turns eastwards, nearly to Fulmer, owing to the denudation that has formed the Hedgerley valley and separated the Beaconsfield outlier. The broadest space taken up by the Reading Beds in this district is between Burnham, Hedsor, Woburn Green, and Hedgerley ; but over a great part of it they are covered by gravel.

A short distance N. E. of Burnham Grove a junction of this formation with the Chalk was to be seen in August 1859. The top of the Chalk was very regular and even, with a slight dip to the south. On it was greensand about two feet thick, with oyster shells and a few small flints ; and this again was overlain by red mottled clay.

" On the road near Batten's Barn there is plastic clay in the ditch. At Foxes Den there is a swallow-hole, half way down which the chalk may be seen ; and in a hole near a cottage in Cavebrook Wood I saw 30 feet of gravel and sand on chalk."*

About a third of a mile nearly south of Hedsor the road down the hill towards the Thames shows the following beds in descending order :—

Gravel - -	Dark brown gravel.
	Brown sand, with a little gravel.
Reading Beds	Light-brown clay.
	Pink and pale blue clay.
	Very pale bluish clay, with lenticular layers of crimson-red sand.
	Pinkish clay, somewhat sandy.
	Brown sandy clay, with flints and pebbles.
Chalk-with-flints.	

The section was anything but clear when I saw it (December 1857), and I then knew next to nothing of the Tertiary formations of these parts.

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* From Mr. Polwhele's Note-book.

The brickyard on the hill half a mile north of Hedsor gives a better section of the same formations; the general order of the beds shown by the various parts of the pit in April 1859 being:—

		ft.
Dark reddish-brown gravel; consisting of flints, pebbles of quartz-rock, and quartz, and a few pieces of greywether-sandstone		over 12
Reading Beds	Variously coloured clays, probably from	15 to 20
	Light-coloured sands, the upper part clayey	about 5
	Bottom-bed; greenish clay and clayey sand, with flints at the base	2

"On the road from Blake's Wood to Woburn Green there is a "junction-section of the Reading Beds and the Chalk; but the plastic "clay of the former has slipped down the hill in places.

"In sinking for chalk about 200 yards south of Overs, 40 feet of "gravel and 20 feet of clay were found before touching that rock, "according to the workmen."*

For some distance eastwards there are now no sections, as far as I know, and I shall therefore give Mr. Prestwich's description of those that were formerly to be seen:—

"From Starveall to Hedgerley is a succession of sections, which are "interesting from their exhibiting the very rapid structural changes "which take place in these sands and mottled clays." Between two sections, at Hedgerley and Penlands, "less than half a mile apart . . . " . . . the mottled clays almost entirely disappear and are replaced by "sands."†

The details of the Penlands section, given elsewhere by Mr. Prestwich,‡ are as follows:—

		ft.
Ochreous Gravel		2 to 3
Reading Beds 40 feet.	Mottled clay	4
	Light-coloured sands, with a few irregular seams of mottled clay	30
	Light bluish clay	4
	Greensand, clay, and flints	2

The Hedgerley section was at a brickyard on the slope of the hill, and the beds shown were§:—

		ft.
London Clay	Brown and bluish clay with *Septaria.*	
	Brownish clay.	
	Basement-bed: Blackish clayey sand and greensand, underlaid by flat tabular masses of greensand with a calcareous cement, and containing a few flint-pebbles.	
Reading Beds, 40 feet.	Mottled clays: Light greenish-grey and red, with a few layers of sand	30
	Fire-brick earth	5
	Greensand, clay, and flints	5
Chalk.		

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* From Mr. Polwhele's Note-book.

† Journ. Geol. Soc. vol. x. pp. 90 and 91.

‡ Water-bearing Strata around London, p. 26.

§ Journ. Geol. Soc. vol. vi. p. 268; and Water-bearing Strata around London, p. 25.

From Fulmer the Reading Beds spread northwards, capping the hills on the western side of the Misbourn valley to some point between the Chalfonts; and capped as far as Gerards Cross by London Clay, and everywhere by gravel, which latter makes the northern boundary very doubtful.

Plastic clay occurs beneath the brick-earth and gravel at Gold Hill, and "in a pit on the top of the hill, about three-quarters of a mile south " of Chalfont St. Peter, gravel was shown resting in a hollow of plastic " clay, with sand beneath, of which last there was said to be from 30 " to 40 feet."*

At Oak End there is a kiln, where the plastic clays of this formation are worked for tiles, &c., but there was no good section when I was in that neighbourhood, neither do I find any account of one in the notebook of my colleague, Mr. Polwhele: Mr. Prestwich, however, remarks that "a somewhat similar section (to that at Hedgerley) is exhibited " at Oak End."†

Hence south-eastwards to the Colne, I know of no section of the Reading Beds, which are hidden by the valley-gravel south of Denham.

On the eastern side of the Colne the Reading Beds rise from beneath the alluvium of the river at a point nearly two miles north of Uxbridge, being followed a short way further north by the Chalk. The junction-line of the two formations winds northwards by Harefield for nearly four miles, and then returns to its normal S.E. trend.

In the lane about a quarter of a mile east of Highway Farm, south of Harefield, there is some mottled plastic clay; and at a less distance to the north of the same place there was, in February 1862, a small pit, from 12 to 15 feet deep, showing a little clay (drifted ?) over coarse light-coloured sand, with a few small flint-pebbles and subangular flints, and near the middle a thin bed of reddish clay. (This sand is much like that in the large pit at Pinner; see p. 29.)

In a large old pit half a mile N.W. of the farm the light greensand of the bottom-bed occurs above the Chalk, and "at the top of a large " chalk-pit by the canal west of Harefield there is here and there a sandy " bed, with black flint-pebbles, and a few subangular green-coated flints, " which may perhaps belong to the bottom-bed."‡

From the hills S.W. of Rickmansworth the winding boundary-line of the Reading Beds runs N.E. roughly parallel with the river Colne to Hatfield Park, and along this tract of country this formation and the overlying London Clay together form a range of hills that rise well above the neighbouring Chalk-country.

Along the road down the hill from Woodcock Hill, by the edge of the park called Harefield Grove, and near the bottom of the small valley, the light greensand of the bottom-bed was turned out of some holes dug for posts.

At the Woodcock Hill Kiln the Reading Beds are worked. In the upper pit there seems to be a little of the brown loam of the basement-bed of the London Clay, capped by a drifted loam with pebbles, and overlying pale plastic clay, which last throws out water from the first. The lower pit, by the kiln, shows about 10 feet of brown sand.

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* From Mr. Polwhele's Note-book.

† Water-bearing Strata around London, p. 25.

‡ From Mr. Trench's Note-book.

In draining the fields on the western slope of the valley a little southward of Piper's Farm plastic clay was found, whilst further S.E. there are three small pits, two in sand, and the other in a pebble-bed.

In the fields south and east of Aston's Lodge, just beyond Moor Park, plastic clay and sand were found in draining; the London Clay and its basement-bed coming on above, towards the Grove Farm. Just to the south there is an "inlier" of the Reading Beds (see p. 28). In the lane about a quarter of a mile west of the last place there is sand, as also in the fields near Sandy Lodge.

On the road south of Hamper Mill there is a long deep cutting, which shows a good deal of sand and a little plastic clay; whilst in the corner of a small wood, about a quarter of a mile further east, there is a small section of a bed of black flint-pebbles in sand, and again "just "north of Oxhey Lodge the pebble-bed occurs."* A little S.E. of the last place there are some old chalk-pits in which the Chalk is capped by gravel and sand, the latter belonging in part to the Reading Beds.

The long railway-cutting south of Bushey Station passes through all the beds from the top of the Chalk to the lower part of the London Clay, the level of the ground rising southwards for some distance, and the slight dip being in the same direction. The section is now in great part overgrown, but according to the measurements of Mr. Prestwich† the Reading Beds are here more than 60 feet thick; I should think, however, that this is a little in excess. The junction with the Chalk may be well seen still, on the eastern side of the cutting, and also the whole of the bottom-bed, which, as Mr. Prestwich says, is "a remark-"able developement of the rolled pebble-bed immediately overlying the "Chalk." The following section is made up from Mr. Prestwich's account, together with my own notes. I should think that the thickness of the mottled clays has been over-estimated.

London Clay and its basement-bed; the latter 5 feet thick, and with many fossils (see p. 54).

		Feet.
Reading Beds 63 feet.	Sands	3?
	Variously coloured mottled plastic clays, with a few beds of sand	35?
	White and light-coloured sand, with flint-pebbles in parts	10
	Bottom-bed, light green-grey sand, sometimes ochreous, with large green-coated flints at the base, and black flint-pebbles throughout	15

Chalk-with-flints.

Along the next cutting to the south the Reading Beds are cut into as far as Oxhey Lane, sand and plastic clay being shown at the bottom, and the London Clay above.

The section at the brickyard at Chalk Hill, and on the southern side of the high road not far from the railway, was as follows (in March 1862):

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* From Mr. Trench's Note-book.

† Journ. Geol. Soc. vol. x. p. 91.

A little brown loam (at the highest part of the pit), perhaps belonging to the basement-bed of the London Clay.

Reading Beds:
- Plastic clay, light bluish- and greenish-grey, mottled with red, 15 to 20 feet.
- Light-coloured sand, not 2 feet shown.
- Pebbles (bottom-bed?) have been got below.

At Bushey Kiln, at the western end of the village, and but little east of the above, there is a good section. The ends only, and not the middle part, of the pit were being worked when I was there (March 1862), and the beds varied slightly; but the following was their general order* :—

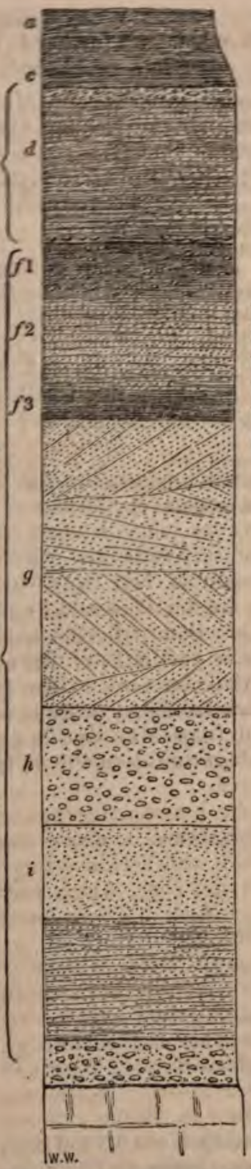

Fig. 2.—General Section at Bushey Kiln.

Drifted clay, in parts sandy, with flint-pebbles, thickness variable.

			Feet.
London Clay.		(a) Brown Clay.	
	Basement Bed.	(c) Pebble-bed; some of the pebbles large, 6 or 8 inches.	
		(d) Brown sandy clay; "large oyster shells at the bottom" (R. Trench), about 6 feet.	
Reading Beds, 35 or 36 feet.		(f1) Green clay, with "race" (irregular calcareous concretions) passing into:— (f2) Greenish and brown clayey sand, with— (f3) Clay below. At the eastern part of the yard these three beds are so very full of race that they become a marl.	over 7
		(g) Light-coloured false-bedded sand	about 12
		The beds below this were not to be seen, but Mr. Trench was told that they were as follows:	
		(h) Pebble-bed	„ 5
		(i) Sand	„ 4
		(k) Loam	„ 5
		(l) Flints in sand	„ 2

Chalk (m).

At Watford Heath Kiln, on the south, there is another good section, the following account of which is taken chiefly from Mr. Trench's Note-book :—

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* This and the like sections at Watford Heath and Hatfield Park Kilns (figs. 3 and 4) are on a scale of 8 feet to an inch, a scale adopted for its convenience for sections of a rather more detailed kind east of London, and which will be published in future Memoirs of the Geological Survey. By using the same scale for all general sections in the London district, comparison will be made the more easy. I have tried to mark corresponding beds by the same letters in these three sections, but I cannot do this with certainty.

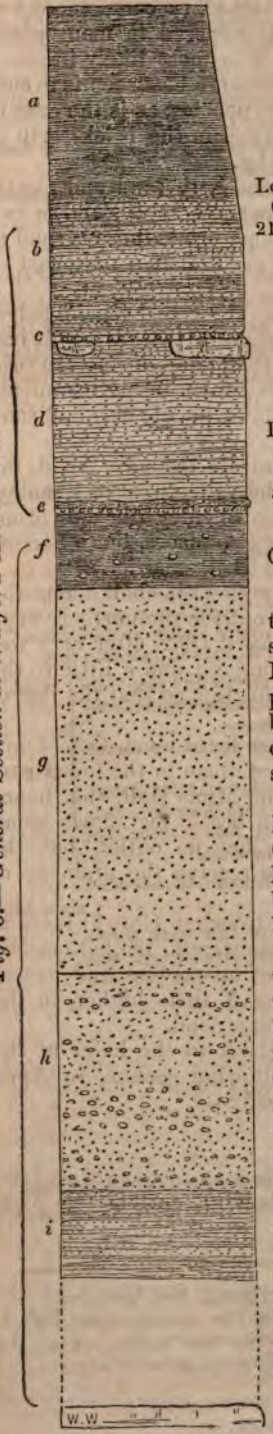

Fig. 3.—General Section at Watford Heath Kiln.

			ft.	in.
London Clay 21½ feet.		(a) Brown clay with selenite passing into	9	0
	Basement-bed.	(b) Brown sandy clay, with a few very badly preserved shells (*Cytherea obliqua, Panopæa*), and small pieces of selenite	5	0
		(c) Flint pebbles, with *oyster-shells* and *shark's teeth*	0	3
		(d) Brown sandy clay, more sandy than the upper bed, with iron-sandstone and a little ironstone* at the base. At the top here and there a bed of soft clayey sandstone, bored by *Lithodomi*, from 6 inches to a foot thick	7	0
		(e) Flint-pebbles, with *oyster-shells* and shark's teeth	0	3
Reading Beds about 37 feet.		(f) Grey and mottled clay, with a few pebbles*	over 3	0
		(g) Light-coloured sand	16	0
		(h) Sand, with beds of pebbles	9	0
		(i) Mixture of sand and clay, light-coloured	3	0
		Not shown (to the Chalk)	6	0

Chalk (*m*).

From Bushey there are none but small sections for some distance. South of Aldenham sand is shown in the lane just N.E. of Burnt Farm; just S.E. of Patchets Green there is plastic clay, above which the loamy basement-bed of the London Clay comes on, and in an old chalk-pit in the hollow to the east there is sand at the top.

In another chalk-pit, between Letchmoor Heath and Round Bush, there is, above the Chalk, sand with pebbles and here and there large unworn flints at the base, which may belong to the Reading Beds. There must be a steady southerly dip here.

N.N.E. from Letchmoor Heath a spur of the Reading Beds runs out by Batler's Green to Newland, the beds above the Chalk having been denuded away along the line of the high road nearly as far south as Kendall Hall, and westward to Letchmoor Heath. Along the road from this last place to Batler's Green sand is first to be seen, then chalk, and then sand again and in greater quantity. At the Green there is plastic clay, and though beyond this the Reading Beds are thickly covered with gravel, the presence of clay is clearly shown by the water thrown out from the latter. Sections are not wanting, however, and one of them is most interesting: it is in a gravel-pit on the hill-top about half way between Radlets and Batler's Green: the gravel will be described further on (p. 69); but the main point of the section is that the bottom of the pit seems to be formed of a hard "pudding-stone" (a conglomerate of flint-pebbles in a sandstone matrix) which is exposed in many parts, and everywhere at the same level; so that it is most likely in place. It belongs, I believe, to the Reading Beds, and where best seen is evenly jointed, the joints passing right through the pebbles, as is the case in many of the loose blocks lying on the surface and in the brick-earth in Herts, &c. There have been other pits near by.

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* There is a specimen of this in the Museum at Jermyn Street. See "Catalogue of Rock Specimens," 3d edit. p. 166.

Along the roads south and east of Newland both sand and plastic clay are shown; west of Radlets there are swallow-holes; and in two old chalk-pits, a little west of south of the same place, there is sand at top, as also at the highest part of another, about half a mile east of Batler's Green.

"At New Organ Hall, in an old pit above the gamekeeper's lodge, "conglomerate was found;"* perhaps like that in the gravel-pit just noticed. Part of the park was drained in 1862, and during the progress of the work I saw London Clay, and its brown loamy basement-bed, a little south of the house, whilst lower down plastic clay and sand were cut into.

The Reading Beds thence reach northwards to Hound's Wood, the Chalk, however, cropping out some way up the valley west of Shenley, and then again take to their N.E. trend, by Shenley Bury to Mims Park, their outcrop forming, between the last two places, but a narrow band between the London Clay range and the Chalk-district.

A little above the church at Shenley Bury there is chalk along the road, but higher up, to the south, sand. Just outside the northern edge of Combe Wood, west of this road, I saw (in April 1862, after very wet weather) some small swallow-holes in full action; and a little to the N.E. there is a chalk-pit showing sand at the top, so that the line of junction with the Chalk is fairly marked here.

Near North Mims the Tertiary beds have suffered much from denudation southwards, so that the Chalk is bare of them in the lower part of the valley thus formed, to half a mile beyond Mims Hall, and thence westward to Pink Farm and Rabley. "The brook that flows along "this valley from Rabley to North Mims has no outlet, but the "water is lost in swallow-holes, which thus receive the drainage of "some 20 square miles of country.

"In the chalk dell N.W. of Warren Farm (Warren Gate ?) there is "a poor junction of the Reading Beds and the Chalk, the bottom-bed "(about 18 inches of brown sand, with black flint-pebbles and green-"coated flints) filling pipes in the latter."* A little higher, in the same direction, light-coloured sand is shown in a pond.

The cutting along the lane from South Mims to the lodge at the southern point of Mims Wood, gave the following section, in April 1862, at a spot near the bend shown on the map:—

Clayey soil.	
Reading Beds	Brown, rather clayey sand.
	Fine, bedded, white sand; at one part alternations of sand and clay for about a foot from the base; at another, thin layers of clay throughout the sand.
	Sand, with flint-pebbles and flints.
Chalk.	

Sand with pebbles may also be seen overlying the Chalk on the southern side of the high road close to where the county-boundary is marked on the map; and "about half a mile to the N.W., where the "other road up Ridge Hill branches off, there is sand."*

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* From Mr. Trench's Note-book.

In a small sand-pit on the western side of the road a little N.E. of Pink Farm, the beds shown, in April 1862, were as follows :—Plastic clay, from about five feet thick to next to nothing, over light-coloured and white sand, mottled with red to about a foot from the top, about nine feet shown. There are some lumps of iron-sandstone lying about, and according to a note of Mr. Trench's, which I suppose refers to this section, there are small pebbles in the sand, and beneath it brown clay.

East of the above, but on the western side of the next road, a little sand is shown above the Chalk in an old pit, and S.E. of this there is a large chalk-pit, at the western end of which the Chalk is capped by from three to five feet of sand, &c., there being at the junction a little clayey greensand and small subangular flints and flint-pebbles (at some parts green-coated, at others not) and here and there some red ironstone.

Close by, and westward, is a large old pit, the sides of which are much hidden and overgrown, so that the section is not clear. At the southern end there is at top grey plastic clay, with much "race" here and there ; then brown and light-coloured sand, and lower down chalk. At the other (northern) side there is nothing but sand over the Chalk, and the top of the latter is as high as, or higher than, the plastic clay and London Clay in the brickyards near by, to the south and west, showing a south-westerly dip. The junction of the sand and the chalk is only shown at one place, where in the lowermost 15 inches or so of the former there are black flint-pebbles and unworn flints (some very large), but no green grains, nor any green-coating on the flints.

South of Pink Farm are two brickyards, one on either side of the lane ; that to the east is new, and is known as Rabley brickyard, the other as Pink Farm brickyard. At the former the pit is in the eastern part of the field, and it showed, in April 1862, from six to eight feet of plastic clay, bluish- and greenish-grey, brown and yellow, mottled with red ; at the latter the Reading Beds were not touched (see p. 50).

"From South Mims to Hatfield Park there are no good sections, and the many swallow-holes give only an approximate boundary-line, owing to the amount of sand in the Reading Beds. S.E. of Mims Street this formation gives rise to a sandy soil in the fields."*

On the road, about 10 or 11 chains east of Warren Gate, and in an old chalk-pit on its southern side, there is light-coloured sand with flint-pebbles, above the Chalk.

From Welham Green and Marsh Moor an irregular-shaped spur spreads over Dulsham Green and Chantry Green, almost to the northern edge of the district included in the map. I think, however, that this may perhaps be separated from the main mass along the channel of the brook east of the first two places ; in which case it would of course be an outlier. The north-western boundary is rather doubtful, owing to a covering of gravel. In the lane N.E. of Downs Farm there is a little light-coloured sand.

From Marsh Moor the boundary-line runs northward, parallel to and east of the high road, to Hatfield. Within the grounds of the house, about a quarter of a mile south of Hatfield church, there is a small pit in light-coloured sand, which, however, will most likely be soon filled up.

At Hatfield the boundary-line runs into the Sheet to the north (46, S.E.), being followed by that of the London Clay, rather more than a mile to the east, and then eastward (into Sheet 47). Many N. and S. valleys have, however, been worn back far enough to show the Reading Beds, and sometimes the Chalk also, along their lower part in the district mapped in the N.E. corner of Sheet 7: thus just east of Hatfield the Chalk occurs a short way up the valley in the park, being hidden, however, by the pond; that formation and the Reading Beds crop out in the valley west of Essenden, and for a less distance up the one east of the same village; and the Reading Beds alone run a little way up the two valleys on either side of Bayford.

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* From Mr. Trench's Note-book.

At Hatfield Park kiln, at the eastern edge of the park, and close to the northern margin of the map, the pits give a very good section from the high-level gravel down to the Chalk. On the eastern side of the road, the higher pit shows the former over London Clay, and the lower London Clay and its basement-bed over the Reading Beds; whilst on the other side the higher pit also shows London Clay with a little gravel, and the lower one all the beds from the basement-bed to the Chalk. The general section that one is thus enabled to make is as follows*:

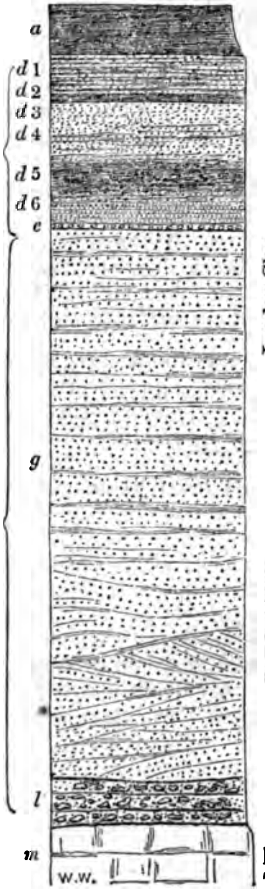

Fig. 4.—General Section of the Tertiary Beds at Hatfield Park Kiln.

			Feet.
		Gravel, composed of various sized pebbles of flint, white and pink quartz, quartz-rock, and some other rocks, and subangular flints, in coarse whitish sand, in parts as much as -	6
London Clay		(*a*) Stiff brown clay, more sandy towards the base - - - - - - -	20
	Basement-bed	(*d* 1) Brown loam, with green grains - - - - - (*d* 2) Thin bed of brown clay - (*d* 3) Olive-green and dull brown sand - - - - - - (*d* 4) Dull brown sand, with green grains and perished shells - (*d* 5) Brown loam, with small nodules of stone and perished shells - - - - - (*d* 6) Finely bedded alternations of olive-green and dull brown sand, with perished shells - - (*e*) Thin bed of flint-pebbles, mostly small - - -	about 7
Reading Beds.		(*g*) White and light-coloured sand, with layers of grey laminated clay; at parts some very small pieces of ironstone, and here and there a flint-pebble; for the most part regularly bedded, but a little false bedding in the lower part - - - -	about 23
		(*l*) Bottom-bed. Flint-pebbles and subangular flints, very dark green (almost black) outside, in sand; the upper part ironshot, the middle grey and greenish-yellow, the base ironshot; greatest thickness - - -	about 2
		Chalk-with-flints (*m*). Junction even, and with a small dip about S.E.	

Mr. Prestwich makes the Reading Beds here to be about 27 feet thick,† whilst in Mr. Trench's note-book the thickness is given as 22 feet: the above is a mean between these. The entire absence of the mottled plastic clays is remarkable. Mr. Trench gives the "basement-bed" a thickness of little more than three and Mr. Prestwich of about five feet. I should think that the section of this bed must have been clearer when I saw it, in February 1863, than before, as neither of those observers seem to have noted its divisions, excepting the pebbles at the base.

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* See foot-note, p. 18.

† Journ. Geol. Soc. vol. vi. p. 270.

East of Hatfield kiln sections of any sort are very rare, but "in a " wood by the brook, less than half a mile west of Bayford church, and " close to the margin of the map, there is a good section of laminated " clay."*

CHAPTER IV.—LOWER EOCENE SERIES (*continued*).

WOOLWICH AND READING BEDS.

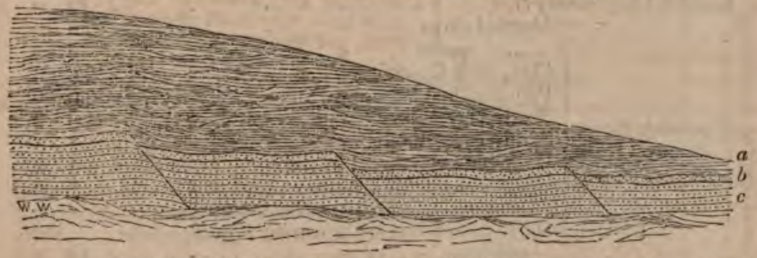
MAIN MASS (*continued*).

At the S.E. corner of the district there is a bay, so to speak, of this formation, which joins on to the rest of the main mass on the east near New Cross, &c. (Sheet 1, S.W.); but the greater part of which is very nearly an "inlier" (see p. 27), being almost surrounded by the overlying London Clay. Indeed it is possible that it may be quite surrounded, and that the London Clay of Herne Hill and Dulwich Hill may join in the valley between, in which case only the most eastern part of this area would join on to the main mass at its outcrop.

This mass of the Woolwich and Reading Beds is quite different in character from all that has been treated of above, as well as from the inliers and outliers that will be noticed further on. We have here beds crowded with fossils, for the most part of a brackish-water class; in fact the "shell-beds" of Woolwich, instead of the unfossiliferous plastic clays and sands of Reading; although these latter are not quite absent.

At the brick-yard about a quarter of a mile S.E. of Brockwell Hall there is a long section, in great part hidden by fallen masses of London Clay, the following beds, however, being shown towards the middle (the clearest part of which is shown in Fig. 5), in April 1863:—

Fig. 5.—Section at Brockwell Hall Brick-yard.



London Clay	(*a*) Stiff brown clay, roughly laminated and jointed—so as to break up into cuboidal pieces—rather sandy towards the base, where there are a few flint-pebbles, and some green grains.
Woolwich and Reading Beds.	(*b*) Buff sand, with shells, 6 to 9 inches. (*c*) Light-coloured sand, with many thin layers of clay, evenly bedded, 6 feet shown.

At the more westerly part of the section the upper sand, which there seems to be rather thicker, is in many places hardened into a crumbling stone, full of fossils, a list of which is given at p. 26. The lower sand is the same bed as that which at Loam Pit Hill, Lewisham (Sheet 1, S.W.) underlies the London Clay, and contains leaves. There are three notable things in this section :—1. That there is no distinct and separate "basement-bed" to the London Clay, that bed being represented merely by the scattered pebbles and green grains in the bottom part of the clay. 2. The upper sand may perhaps represent the sands that in East Kent next underlie the London Clay, and are most likely separable from the Woolwich Beds, though I cannot agree with Mr. Prestwich in classing them as part of the basement-bed of the former formation.* 3. I saw seven small faults with a downthrow of half a foot to a foot, not simply slips in the Woolwich Beds, but affecting the junction with the London Clay.

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* From Mr. Trench's Note-book.

Along the lane about a quarter of a mile N.E. of the brick-yard an oyster-bed (of the Woolwich Series) is shown ; and in the sides of the brook alongside of that lane further southward, sand, clay, and a shell-bed of the same formation may be seen for some distance. About a quarter of a mile N.N.W. of Dulwich College a shell-bed is again at the surface, and just about where the "D" of "Dulwich" is engraved on the map there is some of the regular mottled plastic clay in the brook-channel.

The "Effra Branch" of the "Southern High Level Sewer" of the main drainage works has been carried as a tunnel underneath the "Five Fields," just S.E. of Dulwich Hill ; and our knowledge of the Woolwich Beds in this neighbourhood has been thereby much added to. The sections given by the trial-borings (Nos. 13, 14, and 15) made along the course of the sewer and published in the large plans of the Board of Works, show that the Woolwich Beds are at no great distance from the surface. The structure of the formation was of course better shown afterwards by the shafts for the tunnel, the following details of which have been taken from a paper by Mr. Rickman.† These sections do not quite agree with those of the trial-borings.

Main Shaft.

		ft.	in.
Soil		0	9
London Clay (loamy?)		12	0
Woolwich Beds, about 53 feet.	Mottled clays	8	0
	„ sands	4	6
	Clay, with Cyrenæ	6	0
	Paludina-bed	0	9
	Sandy clay	3	0
	Sandy oyster-bed	1	8
	Dark blue clay, with leaves	4	0
	Green sand, with broken-up shells	7	0
	Shell-conglomerate (greatest thickness)	4	0
	Dark blue clay, with leaves, lignite, shells, and bone	14	0

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* See Journ. Geol. Soc. vol. xviii. p. 267. I am inclined, however, to change the opinion there given, that these sands, &c., belong to the Woolwich Beds, and to think, with Mr. Prestwich, that they are separate from that formation. From all that I have as yet seen I have been led to look on them as a formation separate from both the London Clay above and the Woolwich Beds below. This question will be treated of I trust in a future Memoir.

† Proceedings of the Geologists' Association. No. 6 (1861), p. 106. Mr. Rickman has also given a general section, made up from the different shafts, in Journ. Geol. Soc. vol. xvii. p. 6, according to which from 50 to 60 feet of the Woolwich Beds have been passed through.

Eastern Shaft.

Soil		0	9
London Clay (loamy?)		6	10
Woolwich Beds, about 28½ feet.	Red Sand	5	6
	Black clay, with leaves, lignite, &c.	2	2
	Blue ,, ,, ,,	1	10
	Dark ,, ,, ,,	1	6
	Paludina-bed	0	8
	Broken Cyrenæ	1	0
	Oyster-bed	1	0
	Blue clay, with leaves	1	8
	Dark sand	2	4
	Blue clay, with leaves	1	6
	Dark sand	9	3
	Hard shelly rock.		

Western Shaft.

Soil		0	9
London Clay (loamy?)		9	3
Woolwich Beds, about 28½ feet.	Dark clay	2	0
	Paludina-bed	0	6
	Light-coloured sandy clay, with leaves	1	10
	Blue clay, with oyster-shells	3	0
	Dark sand	0	8
	Yellow sand	2	0
	Blue clay, with leaves	2	6
	Dark loamy sand	0	8
	Blue clay, with thin layers of sand	9	0
	Running sand, with water	4	0
	Light-coloured loamy clay	2	6
	Hard shelly rock		

Mr. Rickman describes the beds shown in the main shaft and the galleries driven from it as "consisting of intercalated bands of dark
" black clay, greenish sand, and hard shelly rock, all running off into
" thin wedges. . . . The tenacious black clay . . was laminated, and
" in breaking up exposed very beautiful specimens of various kinds of
" leaves. These were not mere impressions, but the carbonized sub-
" stance of the leaf still remained. . . . . Oftentimes the leaves formed
" a thin blackish carpet over many square feet of clay. . . The choicest
" specimens may now be seen in the British Museum and the Museum
" of Practical Geology. . . . . Lignite was very abundant, highly
" charged with iron-pyrites, . . . all more or less bored by a large and
" new species of *Teredina*, some of the tubes being nearly half an inch
" in diameter, many having the closed valves of the mollusc at the
" extremity of the calcareous tube."

The "Paludina-bed" is a thin layer of grey clayey limestone (cement-stone), containing *Paludina lenta* in great abundance, the shells often well preserved, but sometimes crushed and flattened. It ranges eastward, keeping the same characters, to Peckham and New Cross (Sheet 1, S.W.), and even to Chiselhurst (Sheet 6).

A more remarkable bed, which as far as I know has not been seen elsewhere, is that which Mr. Rickman has wrongly, I think, called a "shell-conglomerate." It is hardly a conglomerate, but simply a very hard, tough, and rather coarse sandstone, with many shells, and also bones and teeth. In it were found the best specimens of the new genus, *Pitharella* (also found in the Paludina-bed), described by Mr. Edwards,* and also many beautiful specimens of the large new species, *Cyrena Dulwichiensis* (Rickman),* with the marks of the colour-bands.

Great numbers of fine fossils were got here during the progress of the works (1860), and there is a good collection of them in the Geological Museum, Jermyn Street. The list given further on is chiefly taken from that given by Mr. Rickman in Journ. Geol. Soc. vol. xvii. p. 6.

The list of the fossils found in sinking for the foundations of the piers of new Westminster Bridge was made by Mr. Etheridge from specimens given to the Geological Museum. They are in the conglomerate, or pudding-stone, that now and then occurs in the pebble-beds at the top of the Woolwich Beds on the S.E. of London. In this case the black flint-pebbles are few in number, the matrix is the usual calcareous sandstone, and the shells are plentiful.

The fossils from the Brockwell Hall brick-yard were determined by Mr. Etheridge and myself.

FOSSILS OF THE WOOLWICH BEDS. (Sheet 7.)	Under New Westminster Bridge.	Brockwell Hall Brick-yard.	Effra Branch Sewer, Dulwich.
VERTEBRATA.			
Mammalian bones	- -	- -	×
Coryphodon (?) *tooth* †	- -	- -	
Chelonian bones	- -	- -	×
Crocodile scutes	- -	- -	×
Fish, bones, scales (? *Lepidotus minor*), *teeth*	- -	- -	×
MOLLUSCA.			
GASTEROPODA.			
Calyptræa trochiformis, Lam.	×	×	×
Cerithium funatum, Mant.	- -	×	×
——— (? sp.)	×	-	
Fusus (?)	- -	×	×
Melania inquinata, Defr.	×	×	×
Melanopsis brevis, Sby. (?)	- -	- -	×
Natica	×	×	
Neritina	- -	- -	×
Paludina aspera, Michaud. (?) (? *P. Desnoyeri, Desh.*)	- -	- -	×
——— *lenta*, Sol.	×	- -	×
Pitharella Rickmani, Edw.	- -	- -	×
Rissoa	- -	- -	×
LAMELLIBRANCHIATA.			
Bysso-arca Cailltaudi (?) *Bellardi* ‡	- -	- -	×
Corbula	- -	- -	×
Cyrena cordata, Mor.	- -	- -	×
——— *cuneiformis*, Fer.	×	×	×
——— *deperdita*, Sby.	- -	- -	×
——— *Dulwichiensis*, Rickman	- -	- -	×
——— *obovata*, Sby. (?)	- -	- -	×
Modiola elegans, Sby.	- -	×	×
——— *Mitchelli* (?) Mor.	- -	- -	×
Mytilus (?)	- -	×	

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* Geologist, vol. iii. pp. 208–212, and Plate 5. According to Mr. Rickman, the so-called shell-conglomerate occurred at one place in the form of "nodular masses in green shelly sand," but elsewhere was regularly bedded.

† Geologist, vol. vi. p. 113.

‡ Not in Morris's Cat. Brit. Foss.

FOSSILS OF THE WOOLWICH BEDS. (Sheet 7.)	Under New Westminster Bridge.	Brockwell Hall Brickyard.	Effra Branch Sewer, Dulwich.
Ostrea Bellovacina, Lam. (including *O. edulina*)	×	-	×
——— *elephantopus* (?), Sby.*	-	-	×
——— *pulchra*, Sby.	-	-	×
——— *tenera*, Sby.	-	-	×
——— *? sp.*	-	×	
Pholas (?) new sp.	×		
Teredina (large and undetermined species)	-	-	×
Unio Solandri, Sby. (?)	-	-	×
—— (? undescribed sp.)	-	-	×
—— (? sp.)	×		
Polyzoa.			
Flustra	-	-	×
PLANTS.			
Leaves and Seedvessels	-	-	×

The Mammal ***Coryphodon***, Ow. sp. from a well at Camberwell, either just within or just beyond the limits of this map, may be added. In Morris' Cat. Brit. Foss. it is given, by mistake, as from the London Clay.

Well-sections through the London Clay.

The Woolwich and Reading Beds have been passed through in the sinking of many wells in and near London. An abstract of these is given in Appendix 2, p. 102. This memoir, however, would be incomplete without the details of some good section through the London Clay to the Chalk, and I therefore give at pp. 100, 101, some well-sections of which I believe no account has been before published, besides noting in Appendix 2, the publications in which the details of the wells noticed in that Appendix may be found. Any information about other unpublished sections will be thankfully received.

The sections of this formation given by wells in this district show the usual alternations of plastic clay, sand, and pebbles, in varying proportions, whilst in and near London the clay shell-beds of Woolwich dovetail in, and lignite is sometimes found. The pebble-beds (often hardened into a conglomerate) which occur at the top of this formation are also found (see p. 26).

INLIERS.

Besides ***outliers*** of the Reading Beds, that is masses lying out upon the Chalk-country, their connexion with the main mass having been destroyed by the deundation that laid bare the Chalk, and more or less swept off from it the overlying Tertiary beds, there are in this district ***inliers***, or patches lying within the boundary of, and surrounded on all sides by, the overlying London Clay, by the complete denudation of which last formation over the areas in question these lower beds have been brought to the light of day.

As before noticed, it is possible that the strip of this formation mapped on the South of Windsor Castle (see p. 13) may be an inlier; but the gravel on the north and west makes this doubtful, as it altogether hides the Eocene beds between Windsor and the Great Western Railway; and it is also possible that part of the area taken up by the Woolwich Beds at Dulwich may be an inlier (see p. 23).

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* This species not noticed in Mr. S. V. Wood's "Eocene Bivalves" (Palæont. Soc.)

Besides these, five inliers of the Reading Beds have been mapped in Sheet 7. None of them are three miles off the outcrop of the main mass, and all are owing in the first place to a slight rise of the beds, bringing up the lower ones to a higher level than they would have reached if undisturbed.

1. *The Ruislip Wood Inlier.*—The most westerly of these inliers is on the N.E. and E. of this wood, and takes up an area of about half a square mile, forming in great part a rough common-land quite different in character from the surrounding clay hills. At its northern end, in the fields a little east of the toll-bar on the Pinner and Rickmansworth Road, the outcrop is but barely separated from that of the main mass by a covering of the brown loam of the basement-bed of the London Clay; indeed it may perchance join on to the main mass by a very narrow surface-connexion, though it seemed to me not to do so.

The inlier seems to be bounded on the south by the large reservoir; but at this end it may perhaps reach a little farther east than is shown on the map.

In a ditch at the northern end of the new churchyard, a little below the toll-bar, I saw, in February 1862, plastic clay, at the surface nearly up to the level of the church, but higher up capped by the brown loam of the basement-bed of the London Clay, giving a good starting point for drawing the line between the two formations. In the high road just below the church there was also some red-mottled plastic clay.

West of the lane leading from the high road to Ruislip Wood there was, in March 1862, a good section of the basement-bed of the London Clay some few feet below the surface of the ground (see p. 49), showing that the Reading Beds were at no great depth. Along the lane there are also signs of the basement-bed down the gentle slope towards the south, at the foot of which the Reading Beds are at the surface, the London Clay again coming on over them as the ground rises further to the south.

On the common between this lane and the high road there are many sections of the Reading Beds, indeed the shape of the surface of the ground has been quite changed by the pits, many of which have been sunk through to the Chalk. From those along the northern edge of the wood variously-coloured plastic clay has been got, as well as light-coloured sand, whilst those in other parts do not seem to have yielded clay: perhaps the latter do not show the higher beds of this formation. From two pits, close together, I got the following section, remarkable for the occurrence of greensand some way above the bottom-bed:—

Reading Beds {
Clayey greensand.
Light-coloured sand, with a flint-pebble here and there.
Bottom-bed; green clayey sand with flint-pebbles.
Chalk.

Another pit showed light-coloured, false-bedded sand above a regular pebble-bed, the latter being also found at other parts; and a little S.W. of the spot where the "Green Lane" turns off from the high road, there were lying about some very large green-coated unworn flints, clearly from the bottom-bed.

Further south, between the wood and the high road, there is much sand, with plastic clay above on the west, but partly hidden by a drifted loam (brick-earth). On the other side of the high road, just south of the "Green Lane," are some old sand-pits; whilst a little to the east the London Clay seems to set in. About half way between this and the 15th milestone I again saw, in the ditch on the western side of the road, some greensand (but a few inches thick) above light-coloured sand, and Mr. Trench noticed, in the same ditch, "a grey-" wether (see p. 71) in the sand, perhaps in place, these stones being" sometimes met with in the Reading Beds by well-sinkers."

A little further towards Pinner there is sand on the N.E. side of the road, and beyond the 15th milestone there is plastic clay.

On the common to the south shafts have been sunk through the London Clay to the Reading Beds, in order to get the white sand of the latter; plastic clay is found as well, most likely above the sand. The white sand is also got by open pits on a lower part of the common (to the west), where, however, it is in part covered by a drifted loam.

It seems that in this inlier there is mostly a bed of plastic clay at the highest part of the formation, whilst the lower and larger part is sandy. "The Reading Beds are here about 30 feet thick (? more), " and the sections seem to show that the various members are in " lenticular masses. At one place the chalk just below the bottom-" bed was much bored into by lithodomi."*

In those pits, at the northern part of the common, which reached to the Chalk, there was water, in February 1862, up to within a few feet of the top of that rock.

2.—*The Pinner Inlier* is of a more irregular shape, and perhaps slightly larger size, and follows the course of the brook from Wood Hall southwards to Pinner Grove (the more southerly of the two places to which this name is given on the map), and thence westwards to Eastcot.

At the lime-kiln between the first place and Pinner Green chalk is got by means of a shaft, at the highest part of the field, sunk through about 40 feet of the Reading Beds. I was told that about seven feet of "green earth" with flints came next above the Chalk, and that higher up a hard block or bed (perhaps greywether-sandstone) was passed through. The London Clay must come on just to the north. Close to the shaft, and at a rather lower level, is a sandpit, showing many feet of light-coloured sand, bedded and false-bedded, with a thin layer of reddish clay near the middle; the whole much like the beds near Highway Farm, north of Uxbridge (p. 16).

Mr. Prestwich gives the following section of a shaft at Pinner:—†

			ft.
London Clay	Marly Clay		12
	Basement-bed	Sand with shells and *Septaria*	1
		Pebble-bed	1
Reading Beds	Soapy Marl		5
	Mottled Clay		26
	White and ferruginous sand with masses of sandstone, very irregular		4
	Greensand with green-coated flints		4

In clearing out the shallow ditch by the roadside where the last "n" of "Pinner Green" is engraved on the map, red-mottled plastic clay was found; and also in the ditch along the lane a little south of the turnpike. From West End to Eastcot the same occurs in many places on the northern side of the brook, just below the boundary-line of the London Clay.

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* From Mr. Trench's Note-book.

† Journ. Geol. Soc. vol. x. p. 95, and vol. vi. p. 269. These two sections, however, do not agree in detail, and may be at different places.

From Eastcot a narrow strip of the Reading Beds is at the surface along the course of the brook that flows from the South of Pinner Green, and almost joins on to the outcrop at the latter place.

The western end of the inlier is somewhat uncertain, and this formation may, perhaps, crop out further in that direction than is shown on the map; for in the lane that runs by the eastern edge of the wood marked "Ruislip Park," I saw some clay much like the plastic in the ditch about 10 chains above the brook.

Red-mottled plastic clay may be seen at the three roads less than half-a-mile south of the church; and also N.E. of the church, where the lane crosses the brook, up the course of which the Reading Beds are laid bare for a short distance.

It seems that here, as in the foregoing inlier, there is a bed of plastic clay next below the London Clay; and the many places where the former throws out water from the loamy and permeable basement-bed of the latter served as guides in drawing the line between the two formations.

"At Pinner Hill Farm the Chalk was reached at a depth of 97 feet from the surface, through the London Clay and the Reading Beds; resting on it there was greensand."*

3.—Mr. Trench has mapped a very small inlier, along the course of a small brook, from the railway about a quarter of a mile N.W., to the road about the same distance on the west of Pinner Station.

4. *Northaw Inlier.*—For about a mile and three-quarters along the brook-valley, N.E. and E. of the village of Northaw, there is an inlier of the Reading Beds and the Chalk, the latter formation being at the surface in the bottom of the valley for three-quarters of a mile.

I saw this inlier in June 1862. The sections had then for the most part fallen in, and were much hidden by vegetation; but nevertheless they were well worth a visit.

On the more northerly side of the brook and eastward of the old brick-kilns there are many old pits, the most westerly of which show buff sand with black flint-pebbles, at the base more clayey and with almost unworn flints, over chalk. At another pit, very little to the east, there were a few small pieces of soft sandstone containing very small flint-pebbles; and at another the pebbles just above the Chalk were here and there cemented together by iron, and there were some small flat pieces of iron-sandstone and ironstone.

The most easterly pit gave a small but good section, showing an even junction of the Reading Beds and the Chalk, as follows:—

		ft.	in.
Reading Beds	Light-coloured sand (reaching farther up) - about	8	0
	Grey clay, laminated by layers of sand and ironstone; flint-pebbles come on at the base, or rather it passes into - - - - - - -	1	9
	Pebble-bed, with layers of sandy clay; the lower part more sandy and passing into - - - -	2	3
	Dull brown and grey coarse sand, with flint-pebbles irregularly scattered throughout (but chiefly in the upper part) and with *oyster-shells* - - - -	5	0
	Flints, mostly black or very dark green outside, in sand - - - - - - -	0	6
	Hard stony bed with small flints and *allophane*,† fitting closely on to the - - - -	0	0½

Chalk-with-flints, jointed.

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* From Mr. Trench's Note-book.

† There is a specimen of this bed in the Museum at Jermyn Street.

Mr. Prestwich long since noticed here the occurrence of a "fine bed "of the *Ostrea Bellovacina*," and also of "hydrate of alumina—(allo- "phane, a hydrosilicate of alumina)—with the pebbles and flints in im- "mediate contact with the chalk."* An account of this mineral and its occurrence at the junction of Tertiary beds and Chalk has been given by Prof. Morris in Journ. Geol. Soc. vol. xiii. p. 13.

The southern end of the inlier is rather doubtful, as there are no sections in that direction.

5. Another inlier, N.E. of the above, reaches as a narrow strip along the bottom of the next valley from the north of Northaw Wood to the road west of Gough's Oak, with a spur running some way northwards up the side valley between Tallymore and Prestons. "The sand of the "Reading Beds is shown, close by the brook, south of where the 'w' "of 'Newgate Street' and the 'h' of 'Chalk Farm' are engraved "on the map,"† and also by the road at the N.E. corner of Northaw Wood.

CHAPTER V.—LOWER EOCENE SERIES (*continued*).

WOOLWICH AND READING BEDS.

OUTLIERS.

It will be convenient to describe the outliers of the Reading Beds according to the districts into which the chalk-country is naturally divided by the main valleys that run through it. The chief of these is of course that of the Thames, which divides the whole area mapped in this sheet into a northern and southern part. The former of these, however, contains by far the greater part of the chalk-country, and is cut up into subdivisions by the valleys of the many streams that flow through it into the Thames (see p. 1). The description of each outlier, however small, which is shown on the map, will be headed by a number; and to each of the larger and more important outliers a name, from some place on or near it, will be given. The first six districts are north of the Thames, the seventh only being on the south.

1*st District—West of the Loudwater Valley.*

1. Near the southern corner of East Wood, three miles west of West Wycombe, there was, in October 1858, a pit showing a depth of many feet of light-coloured sand. As the Chalk comes to the surface on all sides and at as high a level, or is capped by drift only, the sand must be merely a large pipe in that rock.

At Dell's Farm, about half a mile to the south-east, I saw some brown, red, and blue mottled clay, and along the road a little to the west some light brown and whitish sandy clay and clayey sand. Some of this may belong to the Reading Beds, but I did not think it safe to map it as such.

Rather more than a mile to the south, at Cadmore End, there is some sand which may also belong to this formation; but it is so mixed up with gravel that this is doubtful.

2. *The Lane End Outlier.*—This strangely shaped mass of the Reading Beds radiates in three directions from a central part near Lane

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* Journ. Geol. Soc. vol. x. pp. 92 and 123.

† From Mr. Trench's Note-book.

End,—on the N.W. over Cadmore End Common; on the S.S.W. to Moor's Common, where the beds are much disturbed; and on the E. to Park Hill,—and is capped in many places by London Clay (see p. 52). Each of the three spurs is much broader towards the part away from the centre; so that the outlier is, as it were, made up of three masses joined on by narrow strips to a fourth and central mass.

At Cadmore End Common there is sand; but the boundary-line is hidden by brick-earth; and on the S.E. the sand is covered by gravel. Near Bolter End there is again sand, and on the northern side of the turnpike-road between this place and Lane End there are two swallow-holes; the boundary being marked also by the rise of the ground.

On the common just west of Lane End, by the side of the high road there are some small pits, which showed the following beds (in May 1859):

London Clay.	Stiff brown clay, with *Septaria* and broken fossils. Basement-bed.—Brown loam with layers of clay; green grains in parts; at the bottom a few flint-pebbles of various sizes.
Reading Beds.	Alternations of laminated greenish clay and brown sand, a foot or more thick. Light-coloured sands.

At Lane End there is sand, and just to the east the outlier is almost separated into two.

Around Park Hill I saw no artificial sections; but the boundary-line is marked by many swallow-holes, in some of which the green bottom-bed is shown above the Chalk, and by the sharp rise of the ground.

On the common S.W. of Lane End there are many pits in the sand of the Reading Beds, which is in some of them capped by the loamy basement-bed of the London Clay.

Further in the same direction the Reading Beds continue down the slope of the hill, instead of ending off as one would expect, showing that they have been here affected by some disturbance.

On the common below Stockwell both sand and plastic clay have been found, and it is possible that a spur of sand may stretch over to Moor Farm. At the eastern side of the common a few feet of the Reading Beds were passed through in sinking for chalk, which is worked here by means of a shaft and underground galleries. In a sand-pit between the kiln and Mozzels the following section was shown (May 1859):

Basement-bed of London Clay. Brown clayey sand, with green grains and flint-pebbles, about 2 feet.

Reading Beds. Sand, chiefly white, with layers of laminated iron-sandstone; the upper part very coarse, the lower finer. I was told that 25 feet of sand had been found.

The southern part of the outlier, from Mozzels to Moors End, was very hard to make out, the beds being much disturbed, and thrown, by faults I suppose, into places where one would not at all expect to find them Strangely, too, it would have been almost impossible to map this part at all rightly but for the clear *natural* sections that occur, a very unusual thing in inland Tertiary-districts. These sections, however, were not to be seen without some trouble.

The wood W.S.W. of the ruined church of Ackhamstead does not look, from any spot outside it, a very promising place for geological sections, and the thick underwood would be quite enough to satisfy many explorers as to the need of forcing their way through it. However the water that flows over the moist ground of the common on the north collects, inside the wood, into streams, which, having a sharp fall, cut for themselves channels of some depth, often rather steep-sided and with miniature waterfalls. In one of these the London Clay and its basement-bed (with ironstone, septaria, and fossils) were cut into (May 1859), showing that that formation occurs here at a comparatively low level, far lower than the Reading Beds at Lane End. The streams all flow into a large and deep swallow-hole at the eastern corner of the wood. This is in the Chalk ; but the Reading Beds come on at once ; for I saw the green bottom-bed in a sawpit close by, at the southern edge of the wood. At Moors End there is mottled plastic clay by the roadside. Now both that place and the sawpit are in the bottom of the valley, whilst the rising ground to the S.E., that is in the direction of the general dip of the country (a direction therefore in which one would expect higher beds to come on) is bare Chalk, giving evidence of a fault, or other disturbance, running N.E. from Moors End and throwing down the Tertiary beds on the N.W.

At the most southern point of Moor Common, that is, just above Moors End, I found traces of the basement-bed, and higher up, by the cross-roads, there are some small shallow pits in the London Clay itself. The hill to the west, however, is Chalk, capped by " clay-with-flints " (see p. 63) at the higher parts. This state of things continues further northward, for on the eastern side of the road that, skirting Moor Common, runs N.N.W. along the bottom of the valley, there are frequent signs of the Tertiary beds, whilst on the other side the Chalk rises to a much greater height than that of the London Clay on the common. This gives evidence of a second fault, or other disturbance, running N.N.W. from a point a little west of Moors End to the bend of the road west of Mozzels, and with a downthrow on the east.

There are swallow-holes at the western corner of the wood on the eastern side of the road at the above bend, and here again some of the streamlets that feed them lay bare the beds in the wood, and show along their channels the sand (with pipe-clay and iron-sandstone) and the plastic clay of the Reading Beds. Now not only is the hill to the S.W. chalk, but so also is that to the north, leading one to conclude that there is a third fault, with a southerly downthrow, along the small valley N.W. of Mozzels.

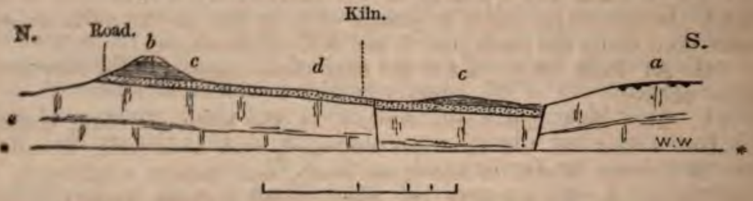
A stream runs along the line of the second and main fault at its northern end, and flows into the swallow-holes in the wood.

On the western side of this fault a small patch of the plastic clay and the bottom-bed of the Reading Series spreads a short way up the flank of the hill along the road to Perrin's Spring; showing that there is here not a fault only, but also a synclinal or trough.

To return to the wood west of Ackhamstead :—It is on the Tertiary beds, and the London Clay comes very near to its north-eastern edge, whilst the rising ground close by, towards Moor Farm, and above Ackhamstead, is Chalk, leading one to infer the presence of a fourth fault, or other disturbance, running N.W. along the edge of the wood to Mozzels ; an inference which is strengthened by the fact that the two S.W. and N.E. faults described above seem to end suddenly on the N.E. (as they also do on the S.W.), as if cut off by another fault at right angles, or nearly so, and with a downthrow on the S.W.

I am led to think that these four disturbances are faults, by the sudden manner in which the Tertiary beds are brought on by them, as well as by the fact that they all seem to end off suddenly at both ends, as if cut off by other faults. I know that to suppose an area altogether surrounded and included by faults, and dropped down in mass, will be thought an almost unwarrantable thing by very many geologists, and I would not have ventured to colour these four faults on the Geological Survey Map had I been able to get over the difficulties of the case in any other way. I worked at this outlier carefully for a long time, and some time after I had mapped it Prof. Ramsay went to Lane End with me, and after a detailed examination of the sections, &c., we were unable to suggest any other explanation.

Fig. 6.—*Section across the Lane End Outlier.*



Horizontal Scale, 2 feet to a mile. Vertical Scale, twice as large.

(*a*) Clay-with-flints (see p. 63).
(*b*) Gravel (see p. 70).
(*c*) London Clay.
(*d*) Reading Beds.
(*e*) Chalk.
** Approximate sea-level.

From Mozzels northwards to Bolter End the boundary-line is much hidden by wood.

3. At Oakington Kiln, near the northern end of the Lane End outlier, a patch of the Reading Beds, consisting of alternations of sand and clay, capped by brick-earth, has been found. At one part of the brickyard the Chalk was not touched at a depth of 25 feet; whilst close by, and at a slightly higher level, it is at the surface, so that this is most likely nothing but a pipe.

4. Just west of Grove Farm, near the eastern end of the Lane End outlier, there is a small hillock of sand, overgrown with wood.

5. By the road nearly a third of a mile S.E. of Wood End Farm, about three miles south of Lane End, I saw some plastic clay. This must fill a pipe, as it is in the midst of the chalk-country, and is not at a higher level than the chalk near by.

6. At Mount Pleasant, about two miles S.E. of High Wycombe, "the ground rises 30 to 40 feet higher (than the chalk near by) in "consequence of an outlier of the sands and mottled clays." * I could see no section of these, however; but in a field (included in King's Wood on the map) at the south-eastern end of the outlier, there was, in April 1859, a small pit showing an uneven junction of the bottom-bed (consisting of about two feet of greenish and yellowish clay, with a little green sand, but no flints) with the Chalk.

7. S.E. of this there is a larger outlier, the northern boundary of which is hidden by the gravel of Flackwell Heath. Along the road up the hill, nearly half a mile east of Pigeon House Farm, plastic clay occurs a little way above the Chalk, as is also the case at about the same level on the roads that run down into the valley at Lower Moor and Woburn Green. Between these last roads the boundary is shown by a slight but well-marked rise of the ground. There is gravel on the southern spur of the outlier, towards Woburn Hill.

8. On Woburn Hill I saw some plastic clay below gravel in the remains of old chalk-wells. This is most likely a separate patch.

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* Prestwich, Journ. Geol. Soc. vol. xi. p. 82.

Outliers.—2nd District.—Between the Valleys of the Loudwater and the Misbourn.

At the highest part of Ash Hill, about two miles westward of High Wycombe, there are signs of the occurrence of a small patch of plastic clay beneath the Gravel.

9. The village of Penn is on a fairly marked outlier, the north-western part of which is, however, hidden by brick-earth and gravel. At Town Farm the Chalk is at the surface, but a little way up the road (to the north) there is plastic clay, as also in the fields on the east, and along the roads just S. and S.E. of the church.

10. At Penn Bury, just to the east, there seems to be a very small thin outlier.

11. Less than half-a-mile further, in the same direction, another outlier comes on, and stretches eastward, with a doubtful boundary in Witherage Wood, to the cross roads, and thence southwards to Bailings. At the northern end plastic clay is shown along the road, whilst at the southern there is sand.

12. A little further east there is a very small patch, the bottom-bed being shown just S.W. of Seagroves.

13. Between Aldiff and Forty Green, S.E. of Penn, there is a small sand-hill.

The hillocks of gravel S. and S.W. of the Penn outlier may perhaps hide traces of the Reading Beds.

14. *The Coleshill Outlier.*—On the S. and S.W. of Amersham there is a large and well-marked outlier of this formation, together with the London Clay, forming the higher ground from Winchmoor Hill and Coleshill Green to the Pest House.

At the western end there is plastic clay; and hence, along their northern boundary, the Reading Beds rise sharply above the Chalk. On this side there are no sections west of Brickwick; but in the hollow just east of that place there is a swallow-hole; and along the road above the Pest House the bottom-bed is shown above the Chalk, with plastic clay higher up. The first is here rather more brown than green, and with the flints coated black, rather than green, ; altogether, indeed, very like the "clay-with-flints" (see p. 63). East and south of this the boundary-line is somewhat doubtful, but there is a swallow-hole at the farm west of Quarrendon.

At the north-western corner of Brentford Wood there is a brick-yard, the pit supplying which (in the wood) gave the following section (July 1859):—

London Clay.	Bluish-grey clay; but little to be seen.
	Basement-bed; but little shown; a clayey sand, said to be 6 or 8 feet thick and to have a bed of pebbles near the middle.
Reading Beds.	Clay, throwing out water from the above.

I was told that in sinking a shaft in the brickyard, for the purpose of getting chalk, nothing but clay was found above that rock.

Along the road to the south there is plastic clay, and thence to Coleshill Green the boundary-line is well marked by swallow-holes, of which there are many—one, indeed, in most of the re-entering angles of the outlier.

In an old pit at the south-western part of the green there is plastic clay on the Chalk, the bottom-bed being absent.

The Reading Beds cannot be very thick in this outlier, I should think; perhaps not much more than 30 feet.

15. *The Frog Hall Outlier.*—On the west of Chalfont St. Giles there is an outlier slightly larger than the above, and like it rising

well above the Chalk, and in great part capped by London Clay, reaching from High Wood eastwards to Hill Farm.

At the western end the Reading Beds are much hidden by gravel, but the northern boundary-line is shown by a swallow-hole nearly a third of a mile eastward of Stockings, and another about the same distance further in the same direction.

At Frog Hall Kiln the section was as follows (July 1859) :—

Gravel.
Basement-bed of London Clay.—Brown loam, with small flint-pebbles at the base, lying irregularly on :—

Reading Beds.	Light blue and yellow mottled plastic clay, throwing out water and passing into crimson-mottled plastic clay.
	Brown and buff clayey sands.
	Bottom-bed; not shown, but said to consist of about a foot of flints capped by coarse sand.

At the lower part of the pit there is brown bedded brick-earth (see p. 67) lying conformably on the sand of the Reading Beds, the two looking like parts of one and the same formation.

On the east and south of the kiln there were no sections, but the boundary-line is fairly marked by the rise of the ground. Near Rowlings it is doubtful, although there is a swallow-hole there, and another nearly half a mile N.W. by the road between Hodge Wood and High Wood.

16. *The Beaconsfield Outlier.*—This large mass has for the most part a doubtful boundary, owing both to the absence of sections and the presence of gravel. The Reading Beds, however, seem to spread over the high ground from Butler's Court to Stampwell, on the east; and to Great Bower Wood, Mount Pleasant, Hedgerley Green, and Bulstrode on the south and south-east, being not far separated from the main mass along a great part of the Hedgerley Valley.

Speaking of this district Mr. Prestwich says, "On Stampwell and " Pitland's Wood Hill the ground rises rather higher, in consequence of " a thin outlier of the mottled clays and sands, round which the gravel " sweeps, barely spreading over it in places."* "In a section in " Pitland's Wood thin patches of subangular flints occur apparently " beneath the mottled clays."†

In a chalk-pit on the western side of the small N. and S. valley at Hedgerley, and just beyond the northern end of the village, a junction of this formation with the chalk is shown. The bottom-bed consists of a foot and a half of light green clayey sand with flints at the base, and above it there is light-coloured sand.

17. There is a patch of the Reading Beds at Taplow. "In a lane " on the north-east of the church (the new one, which is not in " the place where the old one, marked on the map, used to be) there is " a little plastic clay."‡

Outliers.—3rd District.—Between the Valleys of the Misbourn and the Chess.

The Valley of the Chess can hardly be said to reach north of Chesham, where it branches into many dry valleys; but I include in this district the small outliers near the northern edge of the map between Wendover and Wigginton Common.

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* Journ. Geol. Soc. vol. xi. p. 81.
† Journ. Geol. Soc. vol. x. p. 90.
‡ From Mr. Polwhele's Note-book.

18. About three quarters of a mile east of Wendover, at the spot where the B of "Boddington Hill" is marked on the map, I noticed a pipe of sand and plastic clay.

19. By the road about a quarter of a mile S.W. of Choulesbury Church there is a sand-pit some feet in depth. The sand may perhaps be but a large pipe, as there is no proof of its spreading any distance; although, as I noticed some plastic clay lying about at an old brickyard close to the road on the north-west, it is possible that this outlier may reach farther than is shown on the map.

20. At the very edge of the map, on the road N.E. of Choulesbury Church, there is a pipe of sand.

21. The other outliers of this district are much farther to the south, the most northerly one being between Cheneys Lodge and Burton's, about three miles nearly east of Amersham. It is a very doubtful affair: indeed I saw no section; but merely judged, from the rise of the ground, that there was most likely a little of the Reading Beds beneath the Gravel.

22. *The Pollards Wood Outlier.*—Northward of Chalfont St. Giles a mass of the Reading Beds (with a somewhat doubtful boundary, owing to a capping of Gravel and to the woods) forms the higher ground from the northern end of Pollard's Wood to The Vach. In the northern part of the wood there is a pit for the supply of the brickyard at Loudhams (on the north) which showed, in July 1859, the following section:—

				ft.	in.
Reading Beds.		Brownish clay.			
		Brown and grey sand, rather irregular - -	about	0	6
		Mottled plastic clay, regularly bedded - -	,,	6	0
		Grey clayey sand, the uppermost part irregularly hardened and at one part forming an 8-inch bed of sandstone* - - - - - -	,,	3	0
	Bottom-bed.	Pale green sand with a few small patches of crimson and brown, nearly 5 feet, passing into:— Laminated clay of a like colour, with sandy partings, about a foot - - Clayey sand with green grains. A bed of black flint-pebbles, some very small, near the middle, and lower down a bed of the same with many green-coated flints, some large. There are also a few very small quartz-pebbles, about 2 feet - -	,,	8	0

Chalk. A bed of large flints in the top at most parts. A few lithodomus-borings. Junction even.

Due east of Ivy House there is a swallow-hole at the edge of the wood; and by the road, on the south-east, plastic clay and the bottom-bed are shown.

23. *The Newlands Outlier.*—Further toward the south-east a larger mass of the Reading Beds, almost wholly covered by Gravel, and therefore with a doubtful boundary, reaches, with an average breadth of about half a mile, from a little east of The Vach, where it nearly joins

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* There is a specimen of this sandstone in the Museum of Economic Geology. See "Catalogue of Rock Specimens," 3d edit. p. 164. The locality is there wrongly spelt "Peppard's Wood."

on to the foregoing outlier, to a point more than half a mile S.E. of Roberts.

There are no sections, but the boundary is for the most part marked by a slight rise of the ground. Plastic clay is turned up by the plough at the higher part of the field, at the north-western edge of Shrubs Wood; and the same was most likely found at the old kiln just north of Roberts. There is a swallow-hole just south of Bowers; and about a quarter of a mile further south, along the road down the northern slope of the small valley, there is plastic clay; whilst on the other slope, just above the spot where the road from Ninnings joins this one, there is a trace of the green bottom-bed.

24. *The Chalfont Lodge Outlier.*—A wide-spreading mass of the Reading Beds, with a boundary for the most part made doubtful by a thick capping of Gravel, is shown on the map as reaching from the hill-top above Chalfont St. Giles to the Low-level Gravel near Denham.

The northern part is so doubtful that all I can say of it is, that the Reading Beds may end off at any point north of Ninnings, in sinking chalk-wells south of which place sand has been found below the gravel. The southern part is very broad, taking up the whole of the high ground between the Colne and the Misbourn.

"In a small wood just below Mopes a junction-section of the Reading " Beds and the Chalk is shown. On one side of the pit there is plastic " clay with a thick bed of small green-coated flint-pebbles and white sand " beneath: whilst on the other there is scarcely a pebble, but bands of " green sand and clay, with about 15 feet of sand above. North of Tile " House I saw another junction, the order of the beds being plastic clay, " green sand and flints (bottom-bed), and Chalk. Plastic clay is also " shown on the high road more than a mile north of Denham."* The south-eastern end of this outlier is hidden by the valley-gravel.

25. *The Chorley Wood Outlier.*—This well-marked outlier, the boundary of which is however hidden by gravel, spreads from Phillip's Hill, more than three miles westward of Rickmansworth, to Chorley Wood Kiln, on the east.

There is an "old kiln" marked on the map, at the northern part of Phillip's Hill, but I could see nothing of the beds that were worked there.

Just S.W. of King's Farm there is a swallow-hole, and I think that there are others elsewhere, though I have noted but this one.

At Chorley Wood Kiln the following section was to be seen in August 1859. The names in brackets are those given to the different beds by the workmen:—

Reading Beds.	Plastic clay (paving clay). Clayey sand, brown and light-coloured, 1½ feet. Red-mottled plastic clay (tile-clay). Bluish-grey sandy clay (devil). Green sandy clay (fire-earth), with an irregular line of ironstone-nodules (red knob), below which it is more sandy, and passes into:— Green sand. Bottom-bed.—Flint-pebbles, some very large, in sand, greenish towards the top, brown and light-coloured lower down; about 12 feet.
Chalk.	

The pebbles from the bottom-bed here do not break so easily as those that are found in the basement-bed of the London Clay often do; and most of them break with the usual conchoidal fracture of flint, not in the splintery manner of the basement-bed pebbles. (See Memoirs on Sheets 12 and 13 of the Geological Survey Map.)

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* From Mr. Polwhele's Note-book.

Outliers.—4th District.—Between the Valleys of the Chess and the Gade.

26. *The Cowcroft Outlier.*—About a mile and a half east of Chesham there is an outlier of the Reading Beds, with a small capping of London Clay at its northern part, where it forms a hill rising well above the surrounding chalk-country, whilst to the south it is thinner and less marked.

At Cowcroft Kiln there are two good sections. I was told that at the upper of these the clay of the Reading Beds was found beneath the London Clay (see p. 53). The lower one is as follows :—

			ft.	in.
	Buff clayey sand	about	3	0
	Flint-pebbles in clay	„	0	8
Reading Beds.	Yellowish clay	over	2	0
	White sand ; about 3 feet from the top an irregular bed of sandstone, 6 or 8 inches thick passing into :—	about	10	0
	Light-coloured sands with thin layers of clay	„	4	0
	Grey sands and laminated clay, more clayey towards the base	„	8	0
	Flints in dark clay with green sand ; a few small rounded flints, some green-coated. I found a fish tooth in this bed.			

Chalk, with mollusc-borings in the top part. Junction even.

The first two beds may perhaps be drifted : if so, my section will be found to agree in the main with that noted here by Mr. Prestwich in 1853. (Journ. Geol. Soc. vol. x. p. 90.)

In the wood just S.W. of Cowcroft there is a swallow-hole.

The eastern and southern boundaries of this outlier are more doubtful.

27. At Sarratt there is a thin outlier, with a doubtful boundary, reaching from the church northwards to the Green. In the wood just north of the parsonage is a sand-pit, showing lines of black flint-pebbles in light-coloured sand, the first trace of the "pebble-beds" of the Woolwich and Reading Series that I met with in the country under notice (working from the west, and excluding the pebbly bottom-bed).

I was told that in making a well at a cottage at the highest part of Sarratt Green the following beds, most likely belonging to this formation, were passed through in descending order, and with a total thickness of about 35 feet (?) :—Gravel, loamy clay, sand, and large flints in a greenish sandy matrix.

28. I have mapped an outlier on the east of Sarratt Church, the rise of the ground making it most likely that a trace of the Reading Beds exists there beneath the gravel. I saw no section of the former, however.

29. For the same reason I have mapped another outlier at Micklefield Hall, to the south-east.

Outliers.—5th District.—Between the Valley of the Gade and the Valleys of the Ver and Colne.

At Wood Lane End Kiln, more than a mile east of Hemel Hempstead, it would seem that masses of the plastic clay of the Reading Beds are included in the brick-earth, or that there are pipes of the former; for tiles and drain-pipes are made there, as well as bricks, and the sandy brick-earth would be of no use for making them.

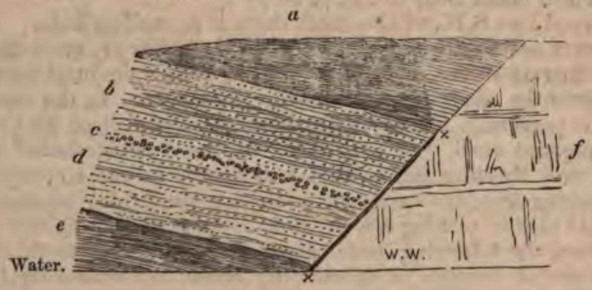
30. *The Bennets End Outlier.*—On the high ground, about a mile and a half S.E. of Hemel Hempstead, there is a faulted Tertiary outlier, against which there abuts, on the north-west, a large mass of brick-earth.

There are here two brickyards; the more northerly one is worked for the brick-earth chiefly (see p. 67), but at the southern part, near the road, the older beds are shown; and I saw the following section of them last January:—

Basement-bed of London Clay.	Brown loam, with a bed of pebbles near the top - - - - - -	about 6 feet.
Reading Beds -	Slate-coloured plastic clay; passing down into:— Slightly sandy clay, green, mottled with crimson, yellow-stained at bottom -	„ 6 „
	Green clayey sand, mottled red; more clayey at bottom of pit - - -	„ 3 „

In the year 1861 the pit at the southern brickyard was cut back until chalk was suddenly touched, and not below, but abutting against the Tertiary beds. The outlier had been mapped some time before, I think in 1859, by my colleague, the late Mr. Richard Trench, who told me that the Tertiary beds here seemed to be disturbed, and were in a sort of hollow in the Chalk; but who saw nothing to show that there was a fault. My attention was drawn to the section by my friend Mr. Evans, who was kind enough to go with me to the spot. The beds, which dip at an angle of about 15° towards the fault, were as follows:—

Fig. 7.—Diagram-section of a Pit near Bennets End.



London Clay.		*a* Roughly laminated brown clay - - - -	from 0 to about 6 feet
	Basement-bed.	*b* Brown loam, over 6 feet - - - - - *c* Flint-pebbles and oyster-shells, about 6 inches - *d* Brown loam, like *b*, 5½ feet - - - -	about 12 „

e Bluish-grey plastic clay of the Reading Beds; holding water.
f Chalk, abutting against the basement-bed of the London Clay.
× × Line of clay along the fault.

The hade of the fault was about 50°. The surface of the chalk was very hard and smooth, and along it there was a layer of clay with "race;" it was not cut through. That part of fig. 7 which is lightly engraved was not actually to be seen. I have drawn it in order that the fault, of the occurrence of which there can be no doubt, may be more clearly understood. I was told that the wall, so to speak, of chalk continued in a straight line nearly N. and S., which would therefore be the direction of the fault.

Last January I again visited Bennet's End, in company with Mr. Evans, and found the section figured above abandoned, and the fault hidden. However a new pit had been dug a little to the west, showing a smaller fault, with its downthrow in the same direction, throwing the London Clay against the basement-bed, and giving the following section :—

London Clay	Brown clay, with a flint-pebble here and there. Basement-bed, light brown loam, 12 feet or more thick, with a little "race;" the pebbles a little above the middle, and with a thin bed of very friable shells in sand, about 2 feet below them. At one part a line of blocks of calcareous sandstone from a foot to 2 feet from the bottom.
Reading Beds.	Bluish-grey and yellow-stained plastic clay, about 8 feet shown.

The boundary of the area of the Reading Beds mapped on the eastern side of the fault (the downthrow of which is on the west) is very doubtful, owing to the quantity of brick-earth over that part: indeed it is not unlikely that there may be nothing but the latter above the Chalk; the outlier, in that case, being altogether cut off on the east by the fault.

Mr. Evans tells me that by the roadside where the "d" of "The Hyde" is engraved on the map (N.E. of King's Langley), light-coloured sand has been found. This is most likely a pipe of the Reading Beds.

31. There is a small outlier at Bedmont, about a mile north of Abbot's Langley. There seems to be clay beneath the thick gravel at the northern end of the village, where there is a pond, and at the other end, along the road to Abbot's Langley, there is a little plastic clay.

32. There is a like unsatisfactory patch of the Reading Beds at Abbot's Langley. Something very much like plastic clay is shown on the road about a quarter of a mile S.E. of the church; and there is a slight but marked rise of the ground round the greater part of the outlier. Mr. Evans pointed out to me a very small ill-marked swallow-hole on the southern side of the road, about a third of a mile S.S.W. of the church. The wells in the village are shallow, which is confirmatory of there being some small thickness of the Reading Beds below the gravel.

Outliers.—6th District.—East of the Valley of the Ver and Colne.

33. At St. Albans there is a thin patch of the Reading Beds with a doubtful boundary, which most likely ends on the south, a little below the cross roads at St. Peter's. In a field beyond the houses N.W. of that church I saw some sand below gravel in a small old pit; and just south of the spot where the "B" of "Bernard's Heath" is engraved on the map, there is an old chalk-pit, showing at the top flint-pebbles in brown clay, which may perhaps be the bottom-bed, discoloured and altered by exposure.

This outlier runs into the sheet to the north (46, S.E.), and the only clear section was in that part of it, in the brickyard at the northern end of Bernard's Heath, where, besides the brick-earth, the following beds were shown (June 1860) :—

Gravel.	
Reading Beds	White and buff sands, with a very few small flint-pebbles, over 8 feet. Bottom bed; about 2 feet.
Chalk.	

I could not get at the bottom-bed; and its thickness was not clearly shown.

34. On the hill top, S.W. and S. of Hill Farm, and a little more than four miles south of St. Albans, there is a small patch of the Reading Beds, barely separated from (if, indeed, it does not join on to) the spur of the main mass at Newland. The Reading Beds are for the most part hidden by pebbly brick-earth, the only section of the former being in the road-cutting about a third of a mile south of Hill Farm, along which, going from the N.E., Chalk, covered only by drifted loam, &c., is shown a little way below the top of the hill; whilst higher up light-coloured sand with layers of clay comes on, and still higher there is green clayey sand mottled with red, the lower part more sandy, and passing downwards into light green-grey sand. At the highest part of the road there is pebbly brick-earth and a little red-mottled plastic clay, which latter most likely passes downwards into the red-mottled clayey sand. Down the same road on the other (S.W.) side the Reading Beds are much hidden by the brick-earth.

It is possible that near Camp Row, between the above and Aldenham, there may be patches of plastic clay below the gravel that spreads over the high ground.

35. In the cutting on the high road, more than half a mile south of Colney Street, and just above the lane turning off to Wild Farm, there is a rather large pipe of the clayey greensand of the bottom-bed. The Chalk comes to the surface higher up, but is soon succeeded by the main mass of the Reading Beds.

36. More than three miles to the east, on the southern side of the high road, between South Mims and Ridge Hill, there is a sand-hillock, almost surrounded by, and nearly joining on to, the main mass.

Outliers.—7th District.—South of the Thames.

On the high flat-topped chalk-country between Henley-on-Thames (just in the Sheet to the west, No. 13) and Wargrave on the west, and Maidenhead and Cookham on the east, there are some well-marked Tertiary outliers, one of which is the finest that I know of on this the northern side of the London Basin.

37. *The Wargrave Outlier.*—Although this is so large and important, yet there is no place of any size on it, and I have therefore named it after the neighbouring village of Wargrave. It consists of a wide-spreading mass of the Reading Beds with two thick outliers of London Clay, the latter forming hills that are most striking objects many miles off, the more so as they are thickly wooded up to the top.

The most westerly point is nearly a quarter of a mile west of Chamberlain's Farm, on the hill east of Wargrave Marsh. From this place the boundary-line follows the contour of the ground, keeping pretty much to the same level, by Cockpoll Green and Warren Row to near Hall Place. Then trending southwards to Littlewick Green, and thence south-westwards by Knowl Hill and Bear Hill to Castle Farm, more than half a mile N.E. of Ruscomb, it gradually reaches a rather lower level, and then rises again N.N.W. to our starting-point. The general dip would therefore seem to be S.S.E. at a very small angle.

The shallow cutting in the lane down the hill from Chamberlain's Farm to Crazey Hill shows a junction of the bottom-bed (about five feet thick, clayey throughout, with a few green grains towards the base) with the Chalk.

Another junction is shown at the brickyard higher up the little valley, and just south of Crazey Hill, the following being the order of the beds; the section did not allow of my measuring their thickness:—

Reading Beds	Light-coloured sands.
	Plastic clay.
	Bottom-bed, for the most part roughly laminated clay.
Chalk.	

There is a swallow-hole in the valley here, and higher up southwards there was, in August 1858, a small pit, showing rather more than ten feet of light-coloured sand.

Just S.W. of Cockpoll Green, at which place the Chalk crops out to the surface, there is a swallow-hole; and the bottom-bed is shown in the road to Dean Place (a little below the cross roads), and in a swallow-hole at Pudder's Farm.

At Warren Row there are swallow-holes within the boundary-line at its re-entering angles, and I have seen water flowing quickly and in fair quantity into some of them. South of this place there is sand; and near the road, a little westward of where the lane from Hurley Bottom joins it, I saw the following section, in March 1859:—

Reading Beds	Mottled plastic clay.	
	Bottom-bed	Bluish-grey clay, roughly laminated by thin sandy layers, about 4 feet.
		Sand with green-coated flints, about a foot.
Chalk.		

Up the hill further east, by the road turning off to Knowl Hill, and just below where the London Clay comes on, there is sand, as also in the fields S.W. of the farm on the south of Prospect Hill.

At the road-turning westward of Hall Place there is a swallow-hole, and another in the wood at the spot where the "y" of "Ashley Hill" is marked on the map.

Along the lane above Chalk-pit Farm there is clay, whilst by the high road at and west of Littlewick Green, and in a chalk-pit farther towards Knowl Hill, there is sand. At the brickyard on the north clay again occurs; but I could see no clear section; and in a pit about a quarter of a mile S.W. of the church at Knowl Hill, light-coloured sand was cut into to a depth of more than 15 feet.

The thin spur that reaches southwards from this part has a doubtful boundary; but the northern side of the railway-cutting at Waycock Field shows some of the green bottom-bed above the Chalk.

The pit in the brickyard north of Bear Hill gave the following section in April 1859:—

London Clay	Brownish clay.
	Basement-bed.—Brown and grey loam, with layers of clay; no fossils or pebbles; about 6 feet.
Reading Beds	Light-coloured sand; many feet shown, but not bottomed.
	Plastic clay; shown at a lower level.

In the field about a third of a mile nearly S.W. of Piggott's Farm, the green sand of the bottom-bed is turned up by the plough, whilst at a higher level there is clay.

West of Castle Farm, this large outlier is not far separated from the main mass N.E. of Ruscomb. I was told that in sinking a well at Castle End Farm chalk was touched at a depth of 14 feet, and that oyster-shells were found above that rock. Just west of the farm, and also at the cross roads on the north, there is sand.

At Hare Hatch there is a swallow-hole, another at the re-entering angle of the boundary-line between that place and Bear Hill, and another about a quarter of a mile to the north-west of the second.

There is again one just south of Chamberlain's Farm, and another, if I remember rightly, about three quarters of a mile S.S.E.

From the section at the Bear Hill brickyard, and from what is shown in the fields near the junction of the outcrop of the Reading Beds, it seems that the London Clay is here underlain by sand, whilst in the country to the west on the contrary a bed of plastic clay forms the topmost part of the Reading Beds. (See Memöir on Sheet 13, p. 23.)

There are some small patches of the Reading Beds within a short distance of the Wargrave outlier, which will now be described.

38. In the railway-cutting a little west of the path over the line to Shottesbrooke there is a small pipe of the bottom-bed on the northern side.

39. About the same distance east of the path another pipe is cut through by the line, part being left on either side.

40. About half a mile further eastward a small outlier is cut into two nearly equal parts by the railway, the cutting of which shows the green bottom-bed, overlain by light-coloured sand, and overlying the Chalk.

41. At Stubbings, east of Ashley Hill, there is a small outlier of sand.

42. On the top of the high chalk cliff of the Thames Valley south-east of Bisham there is a capping of the Reading Beds, the boundary of which is marked by the rise of the ground. At its southern end, in Bisham Park Wood, in the pits for the supply of the neighbouring brickyard, there is much plastic clay, and higher up sand. Further to the north-east gravel caps the hill and hides the Reading Beds; but in a sawpit just west of the cottage on the road at the northern end of the outlier I saw some green and crimson sandy clay.

43. Spreading from the southern end of Cookham Dean for about three quarters of a mile towards Park Corner, and forming a well-marked hill, there is a thicker outlier, the London Clay indeed occurring at its highest part (see fig. 13, p. 83). Plastic clay is shown at the eastern edge of the common, and the Chalk crops out within a very short distance.

At the southern end of the outlier there is sand, and at a higher level plastic clay; and along the eastern boundary there are swallow-holes.

44. A little southwards of the two foregoing outliers is another with a more doubtful boundary, the Reading Beds being hidden by brick-earth on the N.W., N., and N.E. of Park Corner. In a pit between the Golden Ball and Pinkneys there is a good section of the following beds:—

Reading Beds		Bluish-grey green and crimson clay, with a little crimson sandy ironstone at the base - Brown-grey green and crimson sand, mostly coarse, with here and there flint-pebbles and subangular flints - - - -	About 8 feet.
	Bottom-bed	Bluish-grey laminated clay; about 1½ feet - - - Clayey sand with green grains; many flint-pebbles and sub-angular flints, large and small, mostly green-coated; about a foot - - - -	2½ feet.

Chalk, the uppermost part bored by *Lithodomi*. Junction, even. Beds, flat.

Higher up on the common, to the north, there is mottled plastic clay, and still higher brown sand. There is a brickyard here.

45.—On the road about half a mile west of Pinkneys there is a hillock of sand.

46.—A thin patch of the Reading Beds is wholly covered by the gravel outlier just west of Maidenhead, and therefore is not coloured on the map. Its boundary is but a few chains north of the high road, from the branch railway to Vines Hill, at which place it is about the same as that of the gravel on the south of the road; and thence eastwards to the railway it is a little within the gravel boundary.

In the high road at Vines Hill the plastic clay causes a flow of water from the overlying gravel. In a gravel-pit in a field on the south of the road, and no great way west of the railway-station, plastic clay is found at the bottom, and on the western side of the cutting at the station the green bottom-bed is shown between the gravel and the Chalk.

47.—On the southern side of the Great Western Railway, at the 25th mile-post, there is a small outlier not reaching as far as Shoppenhangers.

CHAPTER VI.—LOWER EOCENE SERIES (*continued*).

LONDON CLAY.

Structure.

Whilst the Woolwich and Reading Beds vary very greatly in their lithological structure, "the main body of the London Clay presents "throughout its whole range a uniformity of mineral structure so well "marked and distinct, that either by this character alone, or else by "its organic remains, when present, it can almost always be readily "recognized. . . . . In the Tertiary district westward of London the "London Clay consists of tenacious brown and bluish-grey clays with "layers of septaria," (large irregular-shaped nodular masses of clayey limestone, with divisions, or *septa*, of calcspar or arragonite). . . . . "Im"mediately at its base the London Clay commonly contains a greater or "lesser admixture of green and yellow sands, generally mixed with "rounded flint pebbles, and not unfrequently cemented by carbonate "of lime into semi-concretionary tabular masses. These mixed beds "however never exceed a few feet in thickness, and pass upwards "rapidly into the great mass of the London Clay."* To this part of the formation Mr. Prestwich has given the name of the "basement-bed." It often contains many fossils, and a list of those found in it in this district is given at p. 54.

The upper beds, like the basement-bed, are more sandy than the larger mass of the formation, "and near the top usually mixed with "light-coloured sands in sufficient quantity to form a good brick-clay "without any further addition of sand."† Whilst however the basement-bed is often shown in sections, its presence over the Reading Beds being constant, the topmost part of the formation is of comparatively rare occurrence, owing to denudation, being seldom found at any great distance from the overlying Bagshot Beds.

The fossils of the London Clay, which are very plentiful in some districts, as may be seen by the list given at p. 56, whilst in others they are rare, must have lived in a fairly warm climate. Mr. Prestwich says that "taken altogether, it (the fauna of the London Clay) rather indi- " cates a moderate than a tropical climate, and yet the flora is, as far " as we can judge, certainly tropical in its affinities."* My friend Prof. T. R. Jones tells me that "the indication of sea-depth for the " London Clay afforded by the *Foraminifera* (see p. 59) is that the " water was about 100 fathoms deep."

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* Prestwich, in Journ. Geol. Soc. vol. vi. pp. 253, 4. And at p. 438 of vol. x. the same author says that this formation "everywhere maintains throughout its mass a "nearly uniform mineral character."

† Prestwich, in Journ. Geol. Soc. vol. iii. p. 364.

Speaking of this formation Mr. Prestwich says that the "lithological " character denotes a tranquil and uniform deposit during some length " of time; and as the evidence of fossils proves that the condition of " animal life was similar at the end to that which existed at the com- " mencement of this period, it follows that there must have been " throughout its duration a quiet and gradual subsidence of the bed of " the sea."† "The increasing depth caused by the subsidence appears " to have been constantly neutralized by an accumulation of sediment, " equal, or nearly so, to the amount of depression. By the joint and " counteracting effects of these two causes a nearly uniform and mode- " rate depth was maintained throughout the seas then covering these " districts, enabling the *Panopæa*, *Pholadomya*, *Pinna*, and other " shallow-water genera, to exist all through this geological period, to " the exclusion of the more varied fauna which greater changes of " depth would have produced. But we have indications, as we proceed " further eastward in the London district to Highgate and Sheppey, of " a departure during part of this period from these uniform zoological " conditions; for we here find various species of *Cephalopoda*, *Echi- " nodermata*, some *Brachiopoda*, and of a generally deeper sea Testacea. " . . . . From the operation of more numerous zones of depth, adapted " to the existence of more numerous classes of Testacea, results pro- " bably the more diversified and abundant fauna of Hampstead, High- " gate and Sheppey."‡

Although the fossils are alike throughout this formation, yet the same species are not found equally from top to bottom, and by a very careful comparison of the fossils from different places Mr. Prestwich has been able to make out the existence of four "zones" in this thick mass of clay. He says, "The organic remains of the London Clay are " distributed in groups marking particular zones. . . . Confining our- " selves to the London district, it would appear that, although a great " proportion of the fossils range at intervals vertically throughout the " London Clay, yet their development is very different in different " zones, being abundant in some and scarce in others, whilst each zone " is further marked by a few characteristic species, thus forming dis- " tinct, although nearly related groups. . . . . It must not, however, " be supposed that the fossils are dispersed either vertically or hori- " zontally with any uniformity as to numbers. . . . These zones are " necessarily artificial, as no actual division exists, and the organic " remains and mineral characters are continuous; but they serve to " mark the distinct conditions of the fauna and flora at particular " periods, and show the prevalence generally of like forms on the same " levels; they are not, however, to be taken by any means as con- " stant, but merely as local centres for convenient reference and " grouping."§

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* Journ. Geol. Soc. vol. x. p. 448.
† Journ. Geol Soc. vol. ii. p. 237.
‡ Journ. Geol. Soc. vol. iii. pp. 374, 375.
§ Journ. Geol. Soc. vol. x. pp. 408, 409.

The thickness of the London Clay from top to bottom in this district varies from about 380 to 440 feet; but as remarked above it is rarely that one finds the uppermost beds. The greatest thickness is towards the east, and westward of this district the London Clay is much thinner.*

Range.

This formation, like the Chalk, forms a large part of the district (and for the same reason, its comparative thickness), spreading from the line of outcrop of the Woolwich and Reading Beds to the southern and eastern borders of the map; with the exception of the small areas where it is covered by patches of the Bagshot Sand, of the larger tract taken up by the wide-spread deposits of brick-earth and gravel along the valley of the Thames, of the small inlying areas of the Woolwich and Reading Beds and the Chalk at Windsor, Ruislip, Pinner, and Northaw, and of the bay or re-entering mass of the former formation at Dulwich.

MAIN MASS.

At the S.W. corner of the district the junction of the London Clay and the Reading Beds is hidden by gravel. On the west of the Loddon it seems to run parallel with that of the latter formation and the Chalk, and at a distance of nearly half a mile from it. On the other side of the river the London Clay forms the slightly rising ground of Hurst.

Nearly three-quarters of a mile S.W. of Haines Hill a section of the basement-bed was shown in September 1858, in the ditch, then freshly cut, on the west side of the road leading to Hurst Green. Near the cross roads there was clayey sand with *Ditrupa*, *Ostrea*, *Pectunculus*, and other shells, and flint-pebbles; further towards the Green there was brown clay with "race" (irregular-shaped calcareous concretions); beyond this light bluish-grey and brown mottled loam; then brownish sand with flint-pebbles; and farther still the same without pebbles. I could not make out the superposition of the different members of the basement-bed here, but it is clear that together they take up a great space at the surface.

I was told that in making a well at Haines Hill this bed, with shells of *Ditrupa*, was found at a depth of about 35 feet; and on the road three-quarters of a mile to the N.E., there are many black flint-pebbles in the ditch, most likely from the basement-bed. Hence eastwards towards Windsor the boundary-line of the London Clay follows that of the Reading Beds at a distance rarely greater than a mile or less than half a mile.

"In the cut made to drain Ruscomb Lake the following section is shown near the bridge on the road from Paley Street to Cox's Bridge:

		ft.	in.
Clayey drift		2	0
London Clay		5	0
Basement-bed	Loam with layers of clay and shells, here and there pebbles	6	0
	Pebbles and oyster-shells	1	0
	Sand, in places hardened into stone	2	0
	Bed of *Ditrupa*	0	2

"A little to the west several pebble-beds may be seen in the section.

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* Journ. Geol. Soc. vol. x. p. 401, and vol. xviii. pp. 263, 270.

"By the bridge at Paley Street the mottled plastic clay of the Reading Beds is capped in places by the bed of *Ditrupa*, here cemented into stone, and over which a reddish and then a yellowish clay come on, but no pebble-bed. The basement-bed, with *Ditrupa*, is again shown at the brickyard at Stud Green (see p. 13).

"Close to Bone (? Bourne) Bridge, more than two miles south of Maidenhead, there is a section of a hard slab-like sandstone."*

In 1821 the late Mr. H. Warburton, F.R.S., noticed a set of fossils from the sandstone in the basement-bed, and made the following remarks on the section that yielded them :—"The place from which " these stony concretions were taken is the watercourse lately made " for the purpose of draining the newly-inclosed lands of Windsor " Forest, on the road that leads from Holyport to Binfield. The sand " with its concretions there rests upon variegated plastic clay."† A list of these fossils is given at p. 54, as also of some from "Bray Cut," perhaps a part of the same section.

"In some ferruginous sand thrown out of a pond near the cottage a quarter of a mile west of Mount Scipput, I saw a quantity of *Ditrupa* and a few *oyster-shells*, showing the presence here of the basement-bed."*

From Fifield to Windsor the boundary-line is not clearly marked ; east of Oakley Green indeed it is hidden by the gravel of the Thames. The brickyard a little east of the Cavalry Barracks at Windsor is in London Clay, but the junction with the Reading Beds between this and the Castle is not shown (see also p. 13). A few well-sections in this neighbourhood are given at p. 102, but for the most part they are only of value as showing the depth to the Chalk, the details of the Tertiary beds not being trustworthy.

On the south of its boundary-line west of Windsor the London Clay forms gently-rising hills, above which, in Windsor Great Park and in the district to the south (Sheet 8), the Bagshot Sand comes on (see p. 60). "In the brickyard at the edge of the map (or just in Sheet 8 ?) " south of Warfield, the upper bed of the London Clay (with septaria, " full of fossils) may be seen, and above it the passage-bed from this " formation to the overlying Bagshot Sand."*

There is a tile-kiln at Egham, to which the following remarks of the late Mr. Warburton most likely refer : "In the clay-pits to the south " of the Great Western road, near the foot of the hill, the clay is seen " characterized by its blue colour, by many of the most common of its " fossil shells, and by its septaria."‡

From Windsor northwards beyond Stoke Poges all is hidden by the gravel, which creeps up from the river by a succession of slopes and terraces to a much higher level ; further than this too the higher gravel of Stoke Common, &c., makes the line very doubtful as far as Hedgerley.

At the last place there was once a fine section, from the London Clay to the Chalk (see p. 15). Mr. Prestwich remarked "the " abundance and fine state of preservation" of the fossils of the basement-bed here (see list at p. 54), and that "the concretionary " calcareous masses (containing the fossils) have a brown and ' weathered appearance, and have been here and there bored into by

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* From Mr. Polwhele's Note-book.
† Trans. Geol. Soc. 2nd ser. vol. i. p. 52.
‡ Trans. Geol. Soc. 2nd Ser. vol. i. p. 49.

" some mollusk. These blocks are literally full of shells, amongst " which the *Cardium* n. sp. (? *C. Laytoni*, Mor.), *Cytherea obliqua*, " *Natica glaucinoides* (= *N. labellata*, Lam.), *Nucula*, *Rostellaria* " (= *Aporhais*) *Sowerbyi*, and the *Ditrupa plana*, are most abun- " dant. The shells are well preserved, some with their nacre, but " their substance is rather soft and friable."*

From Hedgerley eastwards the London Clay is cut through by the valley to beyond Fulmer. Then, still covered with gravel, it spreads out northwards to Gerards Cross, when it is again cut back, by the valley of the Misbourn, to Red Hill, whence the boundary-line slopes down to a lower level southwards for about a mile, and sinks below the gravel of the Colne. It would have taken but a little more denudation along the Fulmer Valley to have detached the mass on the north, as an outlier. At the kiln at Oak End the basement-bed has been found (see p. 16); but the sections were so indistinct when I was there that I could not see it.

On the eastern side of the Colne the London Clay plays a more important part in the "shape of the ground," as it forms the greater part of the well-marked Tertiary escarpment that reaches to the N.E. corner of the district (see p. 96). Its boundary-line rises from below the alluvium at a spot about a mile and a half north of Uxbridge, and follows that of the underlying Reading Beds, excepting when the latter formation runs out in spurs over the Chalk.

"At the western corner of the wood just S.E. of Harefield Grove, " the basement-bed was shown in a saw-pit,"† and it also occurs at Woodcock Hill Kiln (see p. 16). In the high road at Park Farm, south of Rickmansworth, there is some clay much like London Clay; and in draining the fields near Aston's Lodge, in the lower ground just east of Batchworth Heath, both the clay and the basement-bed (brown loam) were often met with (see p. 17).

About half a mile south of Batchworth Heath, and near the outcrop of the Ruislip Wood Inlier of the Reading Beds (see p. 28), the basin dug for an ornamental pond in a small new park showed, in March 1862, a section of London Clay, nowhere much over eight feet thick, above the basement-bed. The latter consisted of the usual brown loam with shells and a few flint-pebbles; the former (a list of which is given at p. 54) mostly in layers, one of which was a very hard stone, and was marked by an abundance of the *Cyprina*; another, lower down, was a more septarian-like stone, full of casts of *Panopæa*; and lower still was another rather hard bed. The most remarkable fossil perhaps was the *Cytherea Bellovacina*, a shell that has been but rarely found I believe in this bed,‡ but of which I got some very good specimens here.

The basement-bed is also shown at other parts of the northern end of the Ruislip Wood Inlier (see p. 28), and at the Pinner Inlier it has been found in sinking shafts to the Chalk (see p. 29).

The London Clay and its basement-bed were both cut through in the railway-cutting at Bushey (see p. 17). The section is now hidden, but a list of the fossils that were found in the basement-bed is given at p. 54. In the next cutting to the south these beds are again shown, not clearly however, and here also "there are fossils and some

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* Journ. Geol. Soc. vol. vi. p. 268.

† From Mr. Trench's Note-book.

‡ Though plentiful in the sand next below the London Clay in parts of East Kent, which has been classed by Mr. Prestwich with the "basement bed." See p. 24.

" clayey sandstone with lithodomus-borings, like that at Watford " Heath Kiln."*

The basement-bed may be touched at the brickyard at Chalk Hill; and there are good sections of it at Bushey Kiln, where the junction with the Reading Beds is even, and at Watford Heath Kiln (see p. 19). In the section at the last place the topmost bed that has been classed with the basement-bed may perhaps more strictly be a passage from that bed to the London Clay proper.

In draining the fields a little south of Bushey the London Clay was found close to and on the southern side of the brook due south of the church; whilst a very little lower down the valley, or to the west, the brown loam of the basement-bed was shown (1862).

We must now travel some way on our north-easterly journey along the Tertiary escarpment before coming to any good section of this formation. There are however some small signs of the basement-bed here and there: thus by the road-side S.E. of Patchets Green, south of Aldenham, just before reaching the lane to Burnt Farm, there is some of the usual brown loam, and the like was found in making drains just south of New Organ Hall, east of Aldenham (see p. 20).

The London Clay is shown on the high road at Ridge Hill, between London Colney and South Mims. At Rabley brickyard, on the south, the brown loamy basement-bed occurs at the kiln, close by the road; and at Pink Farm brickyard, near by to the west, " there is brown London " Clay, about eight feet thick, over some two feet of the brown sandy " clay of the basement-bed. It is said to be 30 feet more down to the " Chalk."

" There are signs of the basement-bed about a third of a mile nearly " south-west of Mims Hall, on the southern side of the road; and in the " cutting of the Great Northern Railway west of Friday Grove."* Nearly the whole of this cutting is in the London Clay itself.

Hence northwards to Hatfield Park there are no sections, and the hills of London Clay are much covered with gravel; but east of the park the pits at the kiln show the junction with the Reading Beds (see p. 22). The basement-bed is here made up of many members, the olive-green sands being the most remarkable. The fossils were so frail that I could not get a single one in anything like a perfect state. Mr. Prestwich says " the only fossils I could here determine were an " *Astarte* (*Cytherea* ?), *Ostrea*, and teeth of *Lamnæ*."† I can add to these a *Cyprina*.

At the northern end of the Northaw inlier of the Reading Beds there is some clayey sand in the road rather more than ten chains N.E. of the brook, and in a field just by, on the eastern side, there is loam with green grains and flint-pebbles. These most likely belong to the basement-bed.

The cutting for the " Archway Road" at Highgate has yielded very many beautiful fossils from the upper part of the London Clay.‡ " The " first attempt at Highgate was to drive a tunnel through the hill; " but after a tunnel of small dimensions had been driven, this plan " was abandoned in consequence of finding the substratum sandy and

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* From Mr. Trench's Note-book.

† Journ. Geol. Soc. vol. vi. p. 270.

‡ I think that Mr. Prestwich is mistaken in saying that the " beds of sandy clay," in which so many fossils were found " near the level of the road at the Archway, " . . . . are about 110 to 130 feet below the outlier of Bagshot Sands " capping the hill." (Journ. Geol. Soc. vol. x. p. 408). The Bagshot Sand really comes on at the top of the cutting (see p. 62.).

" loose, and incapable of supporting an arch of the dimensions required, and resisting the superincumbent and lateral pressure."* A like bed of greenish clayey fossil-bearing sand, much like parts of the Bracklesham Beds in the Isle of Wight, has lately been found in the tunnel for the railway, but a little to the north of the Archway.

The occurrence of the fossil resin Copaline, or Highgate Resin, in the London Clay here is noteworthy. It "is found in irregular pieces " of a pale yellowish and dirty brown colour, resembling the resin " copal in colour, lustre, transparency, hardness, and difficult solubility " in alcohol."†

Southwards from the escarpment (from Rickmansworth to Hatfield) to the district of the gravel and brick-earth of the Thames Valley, that is, to a line from Uxbridge to London, there are many other sections of the London Clay in railway-cuttings and brick and tile-yards, none of which however call for remarks. On the higher grounds this formation is mostly capped by gravel. Moreover the gravel of the Thames Valley is sometimes cut through and found to be underlain by this clay, which extends beyond the southern margin of our district.

There are also well-sections through this formation (see pp. 100 to 105). They show the presence of the basement-bed, with a thickness of from a foot to five feet, and composed of various proportions of sand, clay, and rock, with pebbles and shells. In the well at the Lower Heath, Hampstead, fossils were found in this bed (285 feet below the surface), for a list of which see p. 54. In his description of this section Mr. Wetherell says that the lower part of the London Clay " abounded with vegetable remains in a compressed and decomposing " state . . . Between the London and plastic clays a hard rock, five " feet thick, was bored through. It abounded with green siliceous " particles, and contained numerous shells, disposed in layers. . . . . In " some parts of the rock were layers of calcareous spar, the surface of " which was beautifully studded with crystals of pyrites. The bed " contained a great many rounded flint-pebbles, some of which were in " a decomposing state ; and a few of the same pebbles were imbedded " in the lower part of the London Clay."‡

On the south of the Thames the London Clay, rising from below the valley-gravel, forms, with a capping of gravel at the highest parts, and at one place perhaps a little Bagshot Sand (see p. 60), the hills of Richmond Park, Putney Heath, and Wimbledon Common ; and on the other side of the Wandle it rises well above the bay of the Woolwich Beds at Dulwich and forms Champion, Herne, Tulse, Brixton, and Streatham Hills on the north and west, Dulwich Hill on the east, and the high ground of Norwood on the south.

The boundary-line north of Dulwich is somewhat doubtful, as before noticed (p. 23), and this formation may perhaps stretch across from Herne Hill to Dulwich Hill.

At the south-western foot of the former, in the brook that runs thence along the eastern side of Brixton, there is stiff dark brown clay like London Clay—I could not get at it—which is capped by gravel a little further towards Brixton.

At the brickyard near Brockwell Hall the junction of the London Clay and the Woolwich Beds is shown (see p. 23). The section is remarkable for the absence of the basement-bed, so constant in all our foregoing sections.

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* Conybeare and Phillips' " Outlines of the Geology of England and Wales " (London, 1822), p. 25.

† Bristow's " Glossary of Mineralogy," p. 93.

‡ Trans. Geol. Soc. 2d ser. vol. v. pp. 131–3.

A little south of this brickyard is another in London Clay alone.

The borings along the course of the Effra Branch Sewer, near Dulwich College and in the Five Fields (see p. 24), passed through the London Clay to the Woolwich Beds, and thereby served as a guide in drawing the line between the two formations.

OUTLIERS.

These are all on outliers of the Reading Beds, none on the main mass of that formation, unless the mass of London Clay between the Valley of the Chess and the Fulmer Valley should prove to be an outlier (see p. 49).

On the Lane End Outlier (No. 2, p. 31) there are six patches of London Clay.

1. The most marked of them forms the hill on the west of the village and is the central part of the whole outlier. On the common by the high road there is a pit showing the basement-bed over the Reading Beds (see p. 32). Many septaria lie about, some (with casts of fossils) from the basement-bed; and there are also, from that bed, some small thin pieces of sandstone, and some of concretionary calcareous sandstone, on which last there are often adherent shells of *Ditrupa*.* In the London Clay itself, which is shown close by, there are fossils; but they are much broken up. Again, in some small pits on the common, S.W. of Lane End, the basement-bed may be seen overlying the Reading Beds, and the clay is shown higher up.

2. The presence of London Clay on Park Hill, the other high point of the Lane End Outlier, is inferred from the height of the ground; there being no section.

3. In a pit at the kiln near Mozzels I saw, in May 1859, a very irregular junction of the basement-bed with the Reading Beds (see p. 32). The former must merely fill a hollow in the latter, as sand seems to have been found on all sides.

4. At the northern end of Moor Common there are some sections of the London Clay, with a few nodular masses of soft sandstone (with indistinct fossils) and ironstone. The basement-bed seems to come in at the lower part; but the whole, which is close to one of the faults that I have been obliged to map (see p. 33), has a disturbed irregular look. At the top there is a bed of clay, most likely reconstructed London Clay, with a layer of small flint-pebbles at its base, and resting directly on the true London Clay.

5. In the wood just N.W. of the above there is most likely a little of this formation, as the ground there is at least as high.

6. Spreading over the central and southern part of Moor Common there is a larger mass, the sections in which have been described before (p. 33.) This may possibly join on to the next outlier on the north.

A list of the fossils from the basement-bed at Lane End is given at p. 54.

7. The higher part of the Coleshill outlier (No. 14, p. 35) is formed of London Clay, the boundary-line of which follows that of the Reading Beds from Coleshill Green north-eastwards. Just above where the

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* There is a specimen of this in the Jermyn Street Museum. See "Catalogue of Rock Specimens, 3d edit." p. 166.

"C" of that place is engraved I saw the following section in a well that was being made (July 1859) :—

Gravel of flint-pebbles.
A little bluish-grey clay, London Clay?.
Basement-bed; light brown loam, 14 feet shown, no pebbles found.

I did not see the end of the work. There is light bluish-grey London Clay on the common near by.

At the bend of the road about two-thirds of a mile to the north there are many flint-pebbles, most likely from the basement-bed.

The section in Brentford Wood has been given before (p. 35). The basement-bed is shown also just north of the kiln. The water that is thrown out from this more or less sandy bed, at its junction with the clay of the Reading Beds, is mostly lost in the swallow-holes at the junction of the latter formation with the Chalk.

8. At the Frog Hall outlier the only section of the London Clay that I saw was at the brickyard (see p. 36).

9. The highest part of the Cowcroft outlier (No. 26, p. 39) is formed of this formation. The upper pit, at the kiln, shows about 15 feet of brown roughly-laminated London Clay, with septaria, above the brown loam of the basement-bed, the fossils from which latter are listed at p. 54. According to the section given by Mr. Prestwich* the bottom three feet of the London Clay consists of "layers of laminated grey and "brown clay," and the basement-bed, which I was unable to see clearly, of a "layer of imperfect septaria full of fossils, half a foot; "light brown sandy clay, two feet; flint-pebbles in clay, a foot," in descending order.

10. At the Bennet's End outlier (No. 30, p. 40) a small patch of London Clay is brought in by the fault, which, at the southern brickyard, has thrown this formation against the Chalk, as shown in fig. 7. The pebble-bed in the middle of the basement-bed contains many oyster-shells, mostly well preserved and often with both valves together. The fossils that have been found here, by Mr. J. Evans and myself, were chiefly from the upper loam, that below the pebbles yielding comparatively few; but at the newer pit a "shell-bed" has been found below the pebbles, and there are lying about some pieces of fossil-bearing sandstone from near the bottom of the basement-bed. A list of the fossils found is given at p. 54. At one side of the newer pit the brown London Clay fills a hollow scooped out in the loamy basement-bed almost down to the underlying plastic clay. The pebbles are not wholly confined to the marked layer in the middle of the basement-bed, there being a few small ones scattered through the loam and in the sandy shell-bed. Mr. Evans has found fossils in the loam at the southern part of the other brickyard.

The large Wargrave outlier (No. 37, p. 42), as before noticed, is in great measure formed of London Clay, which occurs as two large and two or three small outliers.

11. The largest of these forms Bowsey Hill, and the boundary of this thick mass follows the line between the Reading Beds and the Chalk from Bear Hill to the south-east of Warren Row, generally at a distance of about a quarter of a mile, but with a more winding course.

Along the road rather more than half a mile east of Chamberlain's Farm the basement-bed is shown, and in it is a bed of flaggy sandstone at least a foot thick; a little further north, on the same road, just beyond the road turning off to Crazey Hill, I saw the brown loam of this bed (and just below it the sand of the underlying formation); and also less than a quarter of a mile S.E. of Scotland.

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* Journ. Geol. Soc. vol. x. p. 90.

Thence eastwards the clayey nature of the soil, in distinction from the sandy soil here formed by the upper part of the Reading Beds, marks the boundary.

The loamy basement-bed occurs again, however, by the lane about half a mile N.W. of Knowl Hill Church; there is a section of it at the brickyard north of Bear Hill (see p. 43), and I also saw it about a quarter of a mile to the south, just above the house.

12. The other large outlier, forming Ashley Hill, has a less winding boundary, in like manner, however, following that of the Reading Beds. There is no section anywhere; but the basement-bed is shown on the road half a mile S.S.W. of Hall Place. At the south-western boundary there seem to have been some small landslips.

The highest parts of both Bowsey and Ashley Hills are capped by pebble-gravel (see p. 69).

13, 14, 15. There seems to be a thin capping of the basement-bed on the top of Knowl Hill; but I cannot be certain about it; half a mile to the west there is a rather larger outlier, also somewhat doubtful; and between Littlewick Green and Ashley Hill is a very small one.

16. On the highest part of the Cookham Dean outlier (No. 43, p. 44) there is a small patch of London Clay (see also fig. 13, p. 83).

Fossils from the Basement-bed of the London Clay.

In the following table the lists from Holyport, Hedgerley, and Bushey are given wholly on the authority of Mr. Prestwich, and those from Lane End and Cowcroft are so in part.* All these have been revised. The Batchworth Heath and Bennet's End lists are from specimens in the collection of the Geological Survey (got by my friend Mr. J. Evans, of Nash Mills, and myself). I have also added to the Lane End and Cowcroft lists, the collection of the late Mr. Sheldon Wilkinson of Great Marlow having helped much with the former. The Hampstead list is taken from a paper of Mr. Wetherell's (see p. 51). The fossils from "Bray Cut" were determined by my colleague Mr. Etheridge from a collection given to me by Mr. Wetherell. They most likely came from a part of the same long section as those from Holyport.

The fossils the names of which are marked by an asterisk have not been found in the London Clay itself in this district, as far as I can find out.

—	Lane End (p. 52).	Holyport (p. 48).	Bray Cut (p. 48).	Hedgerley (p. 48).	Cowcroft (p. 53).	Batchworth Heath (p. 49).	Bennet's End (p. 53).	Bushey (p. 49).	Hampstead (p. 51).
VERTEBRATA.									
Bone	...	...	...	...	...	...	×		
—— (fish)	...	...	×						
Lamna (teeth)	×	×	...	×	×	×	×		
Otodus	...	...	...	...	...	×			
Fish vertebræ	...	...	...	×					
—— scales and teeth	...	...	...	...	...	...	...	...	×

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* Journ. Geol. Soc. vol. vi. pp. 267–9.

—	Lane End (p. 52).	Holyport (p. 48).	Bray Cut (p. 48).	Hedgerley (p. 48).	Cowcroft (p. 53).	Batchworth Heath (p. 49).	Bennet's End (p. 53).	Bushey (p. 49).	Hampstead (p. 51).
MOLLUSCA.									
GASTEROPODA.									
Aporrhais Sowerbyi, Mant.	×	...	×	×	...	...	...	×	×
**Calyptræa trochiformis*, Lam.	×	×							
Cassidaria nodosa, Brand.	×	...	...	...	...	×			
—— *striata*, Sby.	...	...	...	×					
—— (most likely one of the above sp.)	...	...	×						
Fusus	×	×	...{	× 2sp.?	} ×	×	×		
Natica Hantoniensis, Sby.	...	...	...	×					
—— *labellata*, Lam.	×	× ?	...	×	×	...	...	...	×
—— ? sp.	×	...	...	...	...	×	×		
Pleurotoma	...	×	...	×	...	×	...	...	×
Pyrula Smithii, Sby.	×								
—— *tricostata*, Desh.	...	...	...	×					
Rostellaria, new sp. (? *Aporrhais Sowerbyi*)	...	...	...	×					
Scalaria	...	...	...	×					
Voluta (cast)	×								
LAMELLIBRANCHIATA.									
**Cardium Laytoni*, Mor.	×	...	×	...	...	×	×	...	×
—— *nitens*, Sby.	×	×	...	×	...	...	...	×	×
—— *Plumsteadiense*, Sby.	...	×	×	×	...	×	× ?	×	
—— new sp. (? *C. Laytoni*)	×	...	...	×	...	...	...	×	
Corbula Regulbiensis, Mor.	...	...	...	×					
**Cyprina Morrisii*, Sby.	...	...	...	...	...	×	×		
—— ? sp.	×								
—— or *Cytherea*	...	×							
**Cyrena cuneiformis*, Fer.	...	...	×						
Cytherea obliqua, Desh.	×	...	...	×	× ?	...	×	×	×
*—— *orbicularis*, Edw.	...	...	× ?	...	...	×	×		
—— *ovalis* var. ? Sby. (? *C. orbicularis*)	...	...	...	×	...	...	...	×	
**Glycimeris* ?	...	...	...	×					
**Lithodomus* ?	...	...	...	×					
Modiola elegans, Sby.	× ?	×	...	×					
Nuçula	...	...	×	×	...	...	×	×	×
**Ostrea Bellovacina*, Lam. (including *O. edulina*)	...	...	...	...	×	...	×		
*—— *pulchra*, Sby.	...	...	...	...	...	×			
—— ? sp.	×	...	×	×	...	×			
Panopæa intermedia, Sby.	×	×	× ?	×	...	×	×	×	×
Pecten	...	×							
**Pectunculus brevirostrum*, Sby.	×								
*—— *Plumsteadiensis*, Sby.	×	×	...	×	...	×	× ?		
Solen	...	...	...	...	...	...	×		
**Tellina*	×	×	...	×	...	× ?			
BRACHIOPODA.									
Lingula tenuis, Sby.	×								
ARTICULATA.									
ANNELIDA.									
**Ditrupa plana*, Sby.	×	×	×	×	×	...	×		
PLANTS.									
Fragments of wood	...	×	...	×	...	×	×		
Impression of small exogenous leaf	...	...	...	...	...	...	×		

Fossils from the London Clay in the neighbourhood of London.

The chief places where fossils have been found in this formation are: Highgate (the cutting for the Archway Road, and the brickyard near by; the works of the new railway have also yielded many fine fossils during the last few months), Primrose Hill (railway-cutting and tunnel), Hampstead, Haverstock Hill, Hornsey, Finchley, Whetstone (railway-cutting), Potter's Bar (railway-cutting), Islington (canal-tunnel), Holloway, Copenhagen Fields, Brentford, Wandsworth Common (railway-cutting), and Richmond; besides Clapham, Chelsea (the excavations for the piers of the suspension-bridge), and Wimbledon (well) for *Foraminifera*. The first place has yielded the greatest number of species, owing, I believe, in great measure to the long residence there of so earnest a collector as Mr. Wetherell, whose museum contains a perfect and most choice series of the *Invertebrata* of the London Clay.

I have drawn up the following list from the lists given by Mr. Prestwich,* corrected by Professor Morris's "Catalogue of British Fossils" (2d edit.), and enlarged by the more recent works of Mr. F. E. Edwards and Mr. S. V. Wood, in the publications of the Palæontographical Society. To my kind friend Professor T. Rupert Jones I am indebted for the lists of *Entomostraca*, and (together with Mr. W. K. Parker) of *Foraminifera*.

SUB-KINGDOM VERTEBRATA.

Class Aves.

Sternum of a small wader.

Class Reptilia.

Crocodilian Bones.
Trionyx.

Class Pisces.

Ætobatis.
Carcharodon.
Cœlorhynchus rectus, Ag.
Lamna elegans, Ag.
Myliobatis Dixoni, Ag.
Notidanus.
Otodus obliquus, Ag.

SUB-KINGDOM MOLLUSCA.

Class Cephalopoda.

Belemnosis plicata, Edw.
Beloptera Levesquei, D'Orb.
Belosepia sepioidea, Blainv.
Nautilus centralis, Sby.
——— *imperialis*, Sby.
Nautilus regalis, Sby.
——— *Sowerbii*, Wetherell.
——— *urbanus*, Sby.
——— (*Aturia*) *zic-zac*, Bronn.

Class Gasteropoda.

Actæon crenatus, Sby.
——— *simulatus*, Sby.
Ancillaria.
Aporrhais Sowerbyi, Mant.
Bulimus ellipticus, Sby.
Bulla attenuata, Sby.
Cancellaria læviuscula, Sby.
Cassidaria nodosa, Brand.
? ——— *Smithii*, Sby.
——— *striata*, Sby.
Cerithium Charlesworthii, Prestwich.
——— *concinnum*, Charlesworth.
Chemnitzia.
Conus concinnus, Sby.
Cypræa Bowerbankii, Sby.
——— *oviformis*, Sby.
——— *Wetherellii*, Edw.
Dentalium acuticosta, Desh.
——— *anceps*, Sby.
——— *nitens*, Sby.

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* Journ. Geol. Soc. vol. x. pp. 414–7 and 419.

Eulima subulata, Sby.
Fusus bifasciatus, Sby.
——— *carinella*, Sby.
——— *complanatus*, Sby.
——— *coniferus*, Sby.
——— *curtus*, Sby.
——— *interruptus*, Sby.
——— *porrectus*, Brand.
——— *trilineatus*, Sby.
——— *tuberosus*, Sby.
Hipponyx.
Melania.
Metula juncea, Sby. (*Buccinum junceum*.)
Mitra parva, Sby., var. *pumila*.
Murex coronatus, Sby.
——— *cristatus*, Sby.
——— *frondosus*, Sby. (not Lam.)
——— *minax*, Brand.
——— *spinulosus*, Desh.
Natica Hantoniensis, Sby.
——— *labellata*, Lam.
——— *sigaretina*, Sby.
Nerita globosa, Sby.
Odostomia.
Ovula (?) *antiqua*, Edw.
Phasianella (?).
Phorus extensus, Sby.
Pleurotoma abnormis, Edw.
——— *acuminata*, Sby. (two var.)
——— *cocciphora*, Edw.
——— *comma*, Sby. (?)*
——— *conica*, Edw.
——— *constricta*, Edw.
——— *denticula*, *Basterot* (*P. plebeia*, Sby.)
——— *dissimilis*, Edw.
——— *fasciolata*, Edw.
——— *flexuosa*, Münst?
——— *fusiformis*, Sby.
——— *granata*, Edw.
——— *helix*, Edw.
——— *inflexa*, Lam. (*P. semicolon*, Sby. ?)*
——— *Koninckii*, Nyst.
——— *lævigata*, Sby. ?
——— *Lehonii*, Roualt.
——— *lissa*, Edw.
——— *macrura*, Edw.
——— *parilis*, Edw.
Pleurotoma Prestwichii, Edw.
——— *prisca*, Sol. ? *
——— *pupoides*, Edw.
——— *rostrata*, Sol. ?
——— *rotundata*, Edw.
——— *Selysii*, De Kon.
——— *simillima*, Edw. (and a variety.)
——— *stena*, Edw.
——— *sulculosa*, Edw.
——— *symmetrica*, Edw.
——— *tæniolata*, Edw.
——— *terebralis*, Lam. (four varieties.)
——— *tereticosta*, Edw.
——— *teretrium*, Edw. (four varieties.)
——— *tricincta*, Edw.
——— *turbida*, Sol. (*P. colon*, Sby.)?
——— *Volgeri*, Phil.
——— *Waterkeynii*, Nyst.
——— *Wetherellii*, Edw.
Pyramidella.
Pyrula angulata, Edw.
——— *nexilis*, Lam. ?
——— *Smithii*, Sby.
——— *tricostata*, Desh.
Ringicula turgida, Sby.
Rissoa (?)
Rostellaria ampla, Brand.
——— *lucida*, Sby.
Scalaria reticulata, Sby.
——— *undosa*, Sby.
Sigaretus canaliculatus, Sby.
Skenea (?)
Solarium canaliculatum, Lam.
——— *patulum*, Sby.
Triton fasciatus, Edw.
Turritella imbricataria, Lam.
——— *scalaroides*, Sby.
Typhis muticus, Sby.
Voluta denudata, Sby. ?
——— *elevata*, Sby.
——— *nodosa*, Sby.
——— *protensa*, Sby.
——— *tricorona*, Sby.
——— *Wetherellii*, Sby.
Volvaria (?)

Class Lamellibranchiata.

Anatina (?)
Anomia scabrosa, Wood.
——— *tenuistriata*, Desh. (= *A. lineata*, Sby.)
Arca impolita, Sby.
——— *nitens*, Sby.
Astarte rugata, Sby.
Avicula arcuata, Sby.
Avicula media, Sby.
——— *papyracea*, Sby.
Cardita.
Cardium nitens, Sby.
——— *Plumsteadiense*, Sby.
——— *semigranulatum*, Sby. ?
Corbula cardiiformis, Edw.
——— *globosa*, Sby.

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* These are not given as Lower Eocene species by Mr. F. E. Edwards (Monogr. Palæont. Soc.), and the identifications are therefore doubtful.

Corbula Regulbiensis, Mor.
Cryptodon angulatum, Sby.
——— *Goodhallii*, Sby.
Cyprina planata, Sby.
Cytherea obliqua, Desh.
——— *tenuistriata*, Sby.?
Isocardia sulcata, Sby.
Leda striata, Lam.?
—— *prisca*, Wood?
Lucina mitis, Sby.
Modiola depressa, Sby.
——— *elegans*, Sby.
——— *subcarinata*, Lam.
——— *tubicola*, Wood?
Neæra inflata, Sby.
Nucula amygdaloides, Sby.
——— *Bowerbankii*, Sby.
——— *compressa*, Sby.?
Nucula minima, Sby.
——— *trigona*, Sby.
——— *Wetherellii*, Sby.
Ostrea gryphovinca, Wood.
Panopæa intermedia, Sby.?
Pecten corneus, Sby. (var. *corneolus*, Wood.)
——— *duplicatus*, Sby.
Pectunculus decussatus, Sby.
Pholadomya margaritacea, Sby.
Pinna affinis, Sby.
——— *arcuata*, Sby.
——— *margaritacea*, Lam.
Sanguinolaria compressa, Sby.
Solen affinis, Sby.
Syndosmya splendens, Sby.
Teredina personata, Lam.
Teredo antenautæ, Sby.

Class Brachiopoda.

Lingula tenuis, Sby.
Terebratulina striatula, Sby.

Class Bryozoa.

Cellepora.
Crisia.
Eschara.
Flustra crassa.

SUB-KINGDOM ANNULOSA.

Class Crustacea.

Archæocarabus Bowerbankii, M'Coy.
Cyclocoristes pulchellus, Bell.
Dromilites Bucklandi, Edw.
——— *Lamarckii*, Desm.
Hoploparia Bellii, M'Coy?
——— *gammaroides*, M'Coy.
Scyllaridia Koenigi, Bell.
Thenops scyllariformis, Bell.
Trachysoma scabrum, Bell.
Xanthopsis bispinosa, M'Coy.
——— *Leachii*, Desm.
——— *unispinosa*, M'Coy?

Order Entomostraca (Ostracoda).

Bairdia subdeltoidea, Münst.
Cythere barbata, Sby.?
——— *scrobiculoplicata*, Jones.
——— *triangularis*, Reuss.
——— (*Cythereis*) *Bowerbankiana*, Jones.
Cythere (*Cytheridea*) *perforata*, Reuss, var. *glabra*, Jones.
——— (*Cytheridea*) *perforata*, Reuss, var. *insignis*, Jones.
Cytherella compressa, Münst.
——— *Londinensis*, Jones.
——— *Muensteri*, Roem.

Order Cirrhipedia.

Pollicipes?
Scalpellum quadratum, Darwin.

Class Annelida.

Ditrupa incrassata, Sby.
Serpula heptagona, Sby.?
——— *prismatica*, Sby.
Serpula trilineata, Sby.
Vermicularia Bognoriensis, Mant.
Vermilia crassa, Sby.

Class Echinodermata.

Bourgeticrinus Londinensis, Forb.
Cainocrinus tintinnabulum, Forb.
Cidaris Websteriana, Forb.?
Cœlopleurus Wetherellii, Forb.
Hemiaster Branderianus, Forb.
Ophiura Wetherellii, Forb.
Pentacrinus Oakeshottianus, Forb.
——— *Sowerbyi*, Wetherell.
——— *sub-basaltiformis*, Mill.

SUB-KINGDOM CŒLENTERATA.

CLASS ACTINOZOA.

Dasmia Sowerbyi, M. Edw.
Graphularia Wetherellii, M. Edw.
Leptocyathus elegans, M. Edw.
Mopsea costata, M. Edw.
Stephanophyllia discoides, M. Edw.
Turbinolia Prestwichii, M. Edw.
Websteria crisioides, M. Edw.

SUB-KINGDOM PROTOZOA.

CLASS RHIZOPODA.

Foraminifera.[*]

Bulimina ovata, D'Orb.
——— (*Bolivina*) *punctata*, D'Orb.
Globigerina bulloides, D'Orb.
Lituola nautiloidea, Lam.
Miliola (*Biloculina*) *depressa*, D'Orb.
——— (*Triloculina*) *oblonga*, Montagu.
——— (*Quinqueloculina*) *triangularis*, D'Orb.
Nodosarina (*Cristellaria*) *Cassis*, Ficht. and Moll.
——— ——— *crepidula*, Ficht. and Moll.
——— ——— *cultrata*, Montf. (including *Robulina* of authors.)
——— ——— *Italica*, Defr. (the same as *C. Wetherellii*, Jones.)
——— ——— *rotulata*, Lam.
——— (*Dentalina*) *acicula*, Lam. (the same as *D. acuta*, D'Orb.)
——— ——— *acuticosta*, Reuss.
——— ——— *brevis*, D'Orb.
——— ——— *communis*, D'Orb. (including *D. elegans*, D'Orb.)
——— ——— *consobrina*, D'Orb. (including *D. pauperata*, D'Orb.)
——— ——— *intermittens*, Roem. (including *D. Buchii*, referred to as *D. soluta* (?) Reuss, in Cat. Brit. Fos.)
——— ——— *spinulosa*, Montagu (including *D. adolphina*, D'Orb. and *N. hispida*, D'Orb.)
——— (*Marginulina*) *lituus*, D'Orb.
——— ——— *Wetherellii*, Jones.
——— (*Nodosaria*) *hirsuta*, D'Orb.
——— ——— *ovicula*, D'Orb. (including *N. longiscata*, D'Orb.)
——— ——— *pyrula*, D'Orb.
——— ——— *radicula*, D'Orb. (including *N. humilis*, Roemer.)
——— ——— *raphanus*, Linn.
——— ——— *raphanistrum*, Linn. (including *N. affinis*, D'Orb. and *N. Badenensis*, D'Orb.)
——— (*Vaginulina*) *linearis*, Montagu.
Planorbulina ammonoides, Reuss (including *Rosalina* and *Rotalina*, of various writers.)
——— *Haidingeri*, D'Orb.
——— *Ungeriana*, D'Orb.
——— (*Truncatulina*) *lobatula*, Walker and Jacob.
Pullenia sphæroides, D'Orb.
Pulvinulina elegans, D'Orb.
——— *Micheliniana*, D'Orb.
Rotalia orbicularis, D'Orb.
Textularia abbreviata, D'Orb.
——— *agglutinans*, D'Orb.
——— *carinata*, D'Orb.
——— *turris*, D'Orb.

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[*] While this Memoir was passing through the press, Prof. T. R. Jones and Mr. W. K. Parker, to whom I owe this list, published a paper "On the Foraminifera of the London Clay" in the "Geologist," vol. vii. (1864), p. 85.

Textularia (*Verneuilina*) *communis*, D'Orb. (= *Clavulina communis*, D'Orb. and *Nodosaria rustica*, Jones.)
Trochammina incerta, D'Orb. (elsewhere named *Spirillina* by mistake).

PLANTS.

Nipadites.

There have, therefore, been found in the London Clay near London 375 species of fossils; besides which 13 of the fossils of the Basement-bed (see p. 54), have not been found in the London Clay proper, making a total of 388 species from this formation in this district; a number which will, no doubt, be increased, as there are many undescribed species, particularly in the magnificent collection of Mr. Wetherell.

CHAPTER VII.—MIDDLE EOCENE SERIES.

LOWER BAGSHOT SAND.

This formation takes up but a small space in our district, having suffered greatly from denudation. It consists of light-coloured sands, often with layers of pipe-clay, and is "everywhere in distinct and "conformable superposition to the London Clay."*

" As to fossils, "the lower division of the Bagshot Sands appears "marked by its negative evidence; not a single specimen have I been "able to obtain in it. . . . I have been informed, however, by "the labourers in some of the sand-pits on the hills west of Egham that "they have occasionally found specimens which I presume from their "description to be casts of shells."*

MAIN MASS.

In Windsor Great Park the Lower Bagshot Sand spreads from the country to the south (Sheet 8), where it takes up a great space, over Lovell Hill and Cranbourn Wood to Cranbourn Lodge, the most northerly point of the main mass; the underlying London Clay is, however, cut into by the brook-valley in the southern part of the wood.

Further east another projecting ridge forms the high ground of Park Place, Cooper's Hill, and Englefield Green (see fig. 1, p. 13), the London Clay being here also at the surface in the brook-valley, just west of the last place, and in the smaller valley a little further in the same direction. "Opposite the church at Englefield Green, there is a large sand-pit, "showing false-bedded coarse white sand, with iron-shot streaks and "layers of pipe-clay, overlain by a drifted bed of pebbles in clay and "sand."†

OUTLIERS.

At the edge of the sheet south of Binfield and of Warfield, and between the two ridges of the main mass just treated of, are the northern ends of three outliers, nearly the whole of which are included in the Sheet to the south (8). In the brickyard near the second of these the passage from the London Clay to this formation is shown (see p. 48).

In Surrey there is a rather doubtful outlier, at the high ground of the southern part of Richmond Park, also spreading into the country to the south. The only sign of the Bagshot Sand in that part of it included in our district is at an old pit at Thatched House Lodge, in which there is fine light-coloured sand beneath the gravel, and unlike the coarse sand that occurs in the latter. The boundary of the outlier is made very doubtful by the gravel which everywhere caps the hill.

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* Prestwich in Journ. Geol. Soc. vol. iii. pp. 380 and 388.
† From Mr. Polwhele's Note-book.

In Middlesex there are three outliers, forming the tops of Harrow, Hampstead, and Highgate Hills, each of which is a marked feature of the landscape. The first is the smallest, and reaches from the north of the church, southwards to Mount Pleasant, and is very narrow at its northern end.

Hampstead.—The largest and best marked of these outliers forms all the highest ground of Hampstead and gives rise to the well-known gorse-covered heath. The irregularly-winding boundary of the sand is well-marked, both by the sharp rise of the ground and by the water thrown out from these permeable beds by the underlying water-tight London Clay; but the northern end of the outlier, in Bishop's Wood, is rather hidden.

The sand spreads from the western end of Lord Mansfield's kitchen-garden, on the road to Highgate, westward nearly to the high road at Child's Hill and southward to Rosslyn House.

There are many pits on the heath, and they show light-coloured sands with thin layers of clay here and there: so much indeed has the sand been dug away that but little of the original surface of the ground has been left.

It will be as well to treat firstly of that part of the outlier on the west of the high road.

The cutting of the road down to North End gives a good section of the sand; and on the south-west of that place there is a bay of London Clay, the Bagshot Sand having been denuded away along the hollow, broad to the N.W., but narrowing towards the flagstaff on the top of the hill. On all sides of this bay much water is thrown out from the lower part of the sands, and this, running over the clay below, forms a regular and constant swamp, in wet weather impassable at most parts and not to be ventured on carelessly at any time, making a most delightful skirmishing-ground for volunteers, as the writer can himself bear witness. South of this sand is often shown along the roads.

At the lower part of the old churchyard the brown sandy clay, that here forms the uppermost part of the London Clay, is found; showing that the Bagshot Sand must come on close above.

In the field just west of Rosslyn House the junction of the two formations is well marked by an ever-flowing spring of very clear water. Just north of the house the sand is shown; and a little further north, in the cutting for a new road down the slope towards the high road, I saw the following beds, in descending order:—sand, clayey sand, sandy clay and clay; the first two belonging to the Bagshot Beds, the others (which were also shown at the brickyard) to the London Clay, and the whole showing a passage between those formations.

The cuttings lately made for the branch of the "Northern High Level Sewer" through Hampstead gave many good and deep sections of the sand, and, at the lower part of the town, of its passage into the London Clay. At one place there was light brown sand capped by light green sand, which latter my colleague Mr. Bristow, who saw the section with me, thought might belong to the Bracklesham Beds (Middle Bagshot): this does not however spread over the whole top of the hill, but seems merely to be a small patch in a hollow on its southern flank; and I think that there is hardly evidence to warrant one in separating this green sand from the Lower Bagshot Beds on the Survey

Map, more especially as I afterwards saw some bluish-green clayey sand lying at once on the London Clay in Well Walk, on the south of the "Vale of Health."

The water of the large pond at the latter place is without doubt held up by the London Clay, whilst on all sides, except to the east, there is sand.

N.E. of this an irregular-shaped spur of the Bagshot Beds stretches for some way into Lord Mansfield's Park, sand being shown in places.

In the farmyard of the park, nearly opposite "The Spaniards," there is a sand-pit; but from this part to the house the boundary-line is by no means the clearer for the artificial changes of the surface of the ground.

I have no means of giving the greatest thickness of this formation at Hampstead; but I should think that it may be from 60 to 80 feet.

Highgate.—This hill is a few feet lower than that of Hampstead, and the capping of the Bagshot Beds is neither so thick nor so wide-spread. Sand is not dug here, and therefore there are but few sections: nevertheless the boundary-line, less winding than that of the Hampstead outlier, is for the most part well-marked. The outlier spreads from a little north of "The Wrestlers" southwards to the higher part of the cemetery and then eastwards a little beyond the Archway.

In Southwood Lane, on the northern slope of the hill, there are constant springs, supplying the cottages near by; indeed water is easily got at most parts of this outlier.

On the southern slope of the hill sand is shown in the lanes on either side of the cemetery, and in Maiden Lane, just below the junction with the high road.

The deep cutting of the Archway Road goes down some depth into the London Clay; so that a small part of the outlier has been artificially cut off from the rest. On the north of the Archway the higher part of the cutting shows sand above sandy clay, and on the south the former may be better seen at the back of some houses on the eastern side of the road.

In the cutting for a new road just below where the first "g" of "Highgate" is engraved on the map much coarse iron-sandstone has been found in the Bagshot Sand. Most of the many blocks lying about contain flint-pebbles.

Besides the three outliers described above there may perhaps be some small patches of this formation; thus by the road-side about a quarter of a mile north of where "Fortune Hill" is marked on the map, between Hampstead and Hendon, there is some light-coloured sand which perhaps may be only a bed in the gravel that occurs there, or, on the other hand, may belong to the Bagshot Beds; in which latter case it would most likely be brought in by a fault with a downthrow to the north, as it is much below the level of the Hampstead outlier, and as the London Clay is at the surface just to the south at a higher level.

Again there may be a small thin capping of sand on the top of Parliament Hill, between Hampstead Heath and Kentish Town.

CHAPTER VIII.—POST-PLIOCENE SERIES.

DRIFTS OF THE HIGHER LEVELS.

I cannot attempt a strictly stratigraphical arrangement of these deposits, which lie irregularly on the foregoing formations. It is very rare in this district to find any two of them at one place, in such manner that one can be sure as to their relative age. It would be almost impossible to mark every spot where they occur, but I think that all the more important places will be found to be here noticed.

BOULDER CLAY.

Mr. Prestwich has noted the occurrence of a patch of this near the northern edge of our district, and I will quote his description of it:—"The new line of railway from Watford to St. Albans passes chiefly "through gravel and chalk. At one place, however, called Bricket "Wood, about midway between those towns, there is a cutting of some "length, and 20 to 30 feet deep, entirely through the Boulder Clay. ". . . . A ballast-pit has recently been opened at the Watford end "of the Bricket Wood cutting, and immediately south of the line, "which exposes a section of much interest. The Boulder Clay has "there almost thinned out, leaving but a seam one to two feet thick, "whilst both above and below it is a thick bed of gravel. The lower "sandy gravel, which consists chiefly of subangular flints and flint-"pebbles, with some quartz, sandstone, and old-rock pebbles, with "subordinate seams of whitish sand, has a clean, washed appearance. "The upper gravel consists of very similar subangular materials, but "is less sandy and darker in colour. . . . I was fortunate enough "to discover, in the lower gravel, a few pieces (but not sufficient to "determine the species) of the tooth and tusk of an elephant. . . . "The lower gravel reposes upon an irregular surface of chalk."* I find the following remark on the Bricket Wood cutting in Mr. Trench's note-book:—"There is here a large developement of brick-earth, con-"sisting of light-brown sand and clay with bands of race." Neither of the above observers say anything with regard to what rocks there may be boulders of in the clay.

Mr. Prestwich elsewhere observes that the Boulder Clay occurs on the Finchley Hills;† and Mr. Trench has noted its occurrence near Little Berkhamstead and Bayford, at the N.E. corner of our district.

In a chalk-pit just north of Bushey railway-station there is a peculiar clay above the Chalk, which I would provisionally class with the Boulder Clay, although as far as I could see there are no boulders in it, and it may be merely the result of the wash of the Tertiary hills on the south, as suggested by my friend Mr. J. Evans, who showed me the section, to which my attention was first drawn by my colleague the late Mr. Trench, and which is as follows:—

Ochreous sandy gravel, partly in pipes—(terrace-gravel).
Clay-drift, bluish-grey at top, the rest light grey; with a three-inch layer of a claret-colour at the base. "A marly clay without sand, which burns to "a white brick."‡
Chalk-with-flints.—The junction with the clay even.

CLAY-WITH-FLINTS.

My description of this deposit in the district to the west does equally well here, and I will therefore quote it:—"The Upper Chalk in this "district is for the most part covered by a stiff brown and red clay, "with large unworn flints. This lies very irregularly on the Chalk,

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* The Geologist, vol. i. (1858), p. 241.
† Journ. Geol. Soc. vol. xii. p. 133, footnote.
‡ From Mr. Trench's Note-book.

" filling pipes in that rock. At its base there are generally a few " inches of black clay, also with flints, in this case black-coated. This " clay is not found in the bottom of the chalk-valleys, which seems to " show that they were worn down to their present form after its " deposition ; but it often extends some way down their sides, showing " that the valleys were at all events partly formed before that period. " As far as I have seen it the 'clay-with-flints' never occurs off the " Upper Chalk "* (that is, the Chalk-with-flints).

When the above was written (in 1860) I could not satisfy myself as to the age or origin of this bed. From a further knowledge of it, however, I have been led to think that it is of many ages, and may be forming even at the present day, and that it is owing in great part to the slow decomposition of the Chalk under common atmospheric action. If a chalk-district were exposed for thousands of years, as many such districts must have been, to the action of rain, &c., the result would be that the carbonate of lime would be slowly carried away in solution by the carbonated water flowing through the cracks and joints of the absorbent rock, and leaving behind the insoluble compact flints and great part of the earthy matter and iron. To these would be added the clayey and loamy wash from the Tertiary-lands, and the remains of beds of that age left in pipes and hollows in the Chalk. The irregular-shaped flints would help in catching and holding the earthy matters, the iron would give a brownish-red colour to the whole, and the irregular decomposition of the Chalk would cause the resultant deposit of these actions to have a varying thickness and an irregular position. The clay and flints left by the dissolution of the Chalk would be present almost everywhere ; whilst the loamy materials that would be formed from the lowest Tertiary beds would most likely be more local; and this is the case, for the loamy brick-earth, next to be treated of, occurs only here and there in the chalk-district. The fact of the clay-with-flints occurring only on the Chalk-with-flints is in favour of this view ; and it is perhaps owing to the comparatively small amount of more or less flat surface taken up by the Chalk-without-flints that there is no such deposit on it. This lower division of the Chalk forms by far the greater part of the slope of the high escarpment and crops out also for some distance on the flanks of the valleys (see p. 4), but the Upper Chalk alone occurs over the wide-spreading table-land.

Of course the process to which I have looked for the origin of the clay-with-flints requires a great length of time.

The bottom-bed of the Reading Beds sometimes looks not unlike this deposit (see p. 35), owing, I suppose, to the decomposition and peroxidation of the protosilicate of iron which gives the green colour to the flints in that bed ; and I take it that the clay-with-flints may be in part older than any of the Post-Pliocene beds ; its formation having begun at whatever time the Chalk was within reach of atmospheric agencies, and gone on up to the present time ; so that it is also amongst the newest deposits.

The facts that in nearly all limestone-districts there is a red soil, and that there is always a red earth in limestone-caves, add I think to the likelihood of the above being the right view of the case. It is not, however, new, as will be seen by the following quotation from a paper by the late Mr. J. Trimmer, who paid great attention to surface-beds, and who disagreed with this view :—" I propose to show that the soils

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* Memoir illustrating Sheet 13 of the Map of the Geol. Survey of Great Britain, pp. 54–5.

" which cover the Chalk of Kent (much the same as in our district) " . . . . are the result of aqueous transport, and not, according to " the prevalent assumption, produced by atmospheric erosion which " during the lapse of ages dissolved and removed the calcareous matter " of the Chalk, leaving behind, as upon a filter, its fine siliceous and " argillaceous particles and its flints."* I neither know who were the holders of the " prevalent assumption," nor can I find any other statement of it than the above ; but I would remark that Mr. Trimmer was not disposed to allow that the chemical action of carbonated water had any sensible effect on the Chalk, as far as can be judged from his published papers (see also p. 11), and that he here groups together the clay-with-flints, the brick-earth, and other materials that may perhaps be merely the result of rainwash down the hill-sides. The unworn and often unbroken character of the flints in the clay is surely in favour of the notion that the deposit is not owing to transport, which would have rounded off the corners and edges of the flints.

I cannot well account for the blackness of the clay next to the Chalk. Can it be caused by the infiltration of water with decomposed vegetable matter in solution, or to the action of iron on such matter (forming a sort of natural ink) ?

Besides the unworn flints, there are also sometimes pebbles of flint and of quartz, as well as pieces of old rocks, in the clay-with-flints.

As to the range of this bed, enough to say that it occurs over nearly the whole of the higher parts of the chalk-district, giving rise to a stiff heavy soil, altogether doing away with " chalk-downs," and supporting great quantities of timber. Its thickness is ever varying, owing to its irregular lie on the Chalk; so that whilst at one spot there may be but a foot of it, at another, only a few yards off, it may reach to a depth of 20 feet or more.

There are many sections, along the road-sides, in the shafts sunk for chalk in the fields, and in the brickyards, that will be noticed under the next deposit.

On the flank of the chalk-escarpment, about a mile S.W. of Bledlow, I saw a pipe of clay with flints, 15 feet or more deep, going from the Chalk-with-flints through the chalk-rock (see p. 5) into the Lower Chalk.

In a field at the southern edge of Pophleys Wood, near the western edge of the district, and nearly seven miles north of the Thames, I found at one place a number of very small black flint-pebbles, from the size of small shot to that of slugs, in the clay.

The northern side of the cutting on the high-road south of Remenham, up the hill on the eastern side of the Thames opposite Henley, gives the best section that I know of. The chalk-with-flints is flat-bedded in the direction of the road. (E. and W.) The surface-clay comes on suddenly on the east in a great pipe, which reaches down to the level of the road, a depth of about 30 feet. Higher up, further east, the Chalk reaches nearly to the surface again, and then there are more pipes, all connected at the top, so that the clay is continuous along the rest of the cutting. Next to, and for a little distance from the Chalk there is dark brown and black clay with unworn black-coated flints ; the other contents of the pipes are brown and red clay, brown loam, brown, red, yellow, and buff sand, and brown gravel, all irregular and with flints, unworn, worn, rounded, and a few green-coated (from the bottom-bed of the Reading Beds). There are also pebbles of quartz, quartz-rock, and other old rocks, and a few small lumps of ironstone. Here and there are black streaks or veins in the beds, and sometimes a patch of blackened gravel. The flints exceed all the other stones both in size and number, many being very large.

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* Journ. Geol. Soc. vol. vii. p. 34.

" At Wood Lane End, east of Hemel Hempstead, the clay-with-flints contains large black brittle paramoudra-shaped flints."*

BRICK-EARTH.

A more valuable deposit of loam, formed perhaps by the mixing up of the sands and clays of the Reading Beds, is not uncommon in the chalk-tract, and is worked for brick-making. It is of various colours and composition, sometimes being dark-brown, bluish-grey and red-mottled, and sometimes light brown ; whilst at one place it is a sandy clay, at another a clayey sand. Like the foregoing deposit, by which it is underlain, it occurs irregularly, filling pipes, often of large size.

Most of the brickyards where the earth is worked are marked on the map. At Highfield Barn, near the edge of the sheet, west of Hambledon, there has been a brickyard ; the pit, about 15 feet deep, showed (in 1858) a gravelly soil, from a foot to four feet thick, over the brick-earth (light-brown clay, loam, and sand). At one part there was gravel below, and this most likely occurs under all parts ; it was sandy at one place, clayey at another, and consisted of flint-pebbles, flints, and pebbles of quartz and sandstone. Some of the brick-earth is of a pale blue colour mottled with red.

At the northern end of the Lane End outlier (No. 2, p. 31) there is brick-earth.

At Marlow Common, west of Great Marlow, it is irregularly capped by a sort of clayey gravel, and underlain, I was told, by clay with large flints, beneath which again was rubbly chalk.

In an old brickyard at Flackwell Heath, about three miles S.E. of High Wycombe, I saw some 12 feet of brick-earth and gravel above chalk.

N.W., N., and N.E. of Wycombe this deposit occurs in abundance, and is in parts remarkable for containing very many blocks of greywether-sandstone (see p. 72), for which indeed the brick-earth is then worked rather than for brick-making. Small pits are dug in the fields, the stones are quarried out and then broken up into small cuboidal blocks for paving and building. The pounding action of the hammer reduces part of the hard stone to a coarse light-coloured sand, like that of the Reading Beds.

At Nobles, a mile and a half N.N.W. of West Wycombe, the greywethers have been thus got ; and at Napple Common and around Walter's Ash, to the east, the brick-earth, sometimes proved to a depth of 30 feet, and then not bottomed, contains many and large greywethers at different depths, and often so close together as almost to form a continuous bed, so much so that Mr. Prestwich was led to think them nearly in place.†

At Speen Hill, to the north, there is a brickyard, and east of this greywethers are again quarried from the brick-earth at Denner Hill, and on the western flank of Bryant's Bottom, close by northwards, at which last place the greywether-bearing deposit spreads from the top of the hill down into the valley. It also runs northward to Hampden Row, and again occurs about half way between Hampden and Prince's Risborough.

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* From Mr. Trench's Note-book.

† Journ. Geol. Soc. vol. x. p. 127.

At the northern end of Clinton Wood, nearly two miles S.W. of Wendover, the brick-earth is worked.

There is a great spread of it at Priestwood and Peterley Commons, west of Great Missenden, and at the northern end of the former there is a brickyard.

Over Wycombe Heath and Penn Wood, and thence towards Winchmoor Hill, there is brick-earth, worked just south of Penn Street; and again between these parts and Wycombe. At the brickyard (Terrier's Kiln), between Hazlemoor and Terrier's, some of the pits, on the southern side of the road, show the loam in parts very red, at others light-coloured, and at some containing a little plastic clay from the Reading Beds, which has been dug to a depth of 30 feet without reaching the chalk; whilst close by to the west there is a chalk-pit, and at the kiln, the on the other side of the road, chalk is also got, there being only with-flints, in parts with some plastic clay, above it.

Between this last place and Penn are two more brickyards, and near the houses on the common, just north of Ash Hill, are pits which show the following beds, very irregular, but in this order:—

Red-mottled brick-earth, gravelly in parts (chiefly at top).
Gravel, almost wholly of flint-pebbles.
Brown and black clay with large unworn flints.
Chalk found below.

At Frog Hall Kiln, near Amersham (see p. 36), the Reading Beds are in part capped by brick-earth, which is gravelly at top, and has gravel alongside of it; but whether the last is the older or newer I could not tell.

E. and S.E. of Wendover there are many wide-spread patches of brick-earth. At Buckland Common there are two old brickyards, and a third still in work shows that the "earth" is very sandy and brightly coloured, being sometimes a pink clayey sand, much like parts of the Reading Beds. The brick-earth at Wigginton Common, further east, is also worked, but the brickyard is just beyond the boundary of this sheet of the Geological Survey Map. A little north of Lee is another brickyard, and another at Hyde Heath, east of Great Missenden, where blocks of pudding-stone have been found in the brick-earth, of which there seems to be two sorts, the lower part being of a lighter colour than the upper.

Between Chesham and Amersham there is a little brick-earth, and also, with gravel, at Chorley Wood Common, N.W. of Rickmansworth. At Shendish, rather more than two miles south of Hemel Hempstead, it has been worked.

At Wood Lane End brickyard, more than a mile east of the same town, there is a very good section, which I saw in company with Mr. Evans of Nash Mills, showing 25 feet of brick-earth, which contains a few pebbles and flints, and is more or less laminated, especially the lower part. The upper part is brown and yellow, the lower buff and whitish, and consists of finely and evenly laminated clayey sand, in which Mr. Evans found an impression of a small *exogenous leaf*. The beds dip inwards towards a centre, sometimes at as great an angle as 35° or 40°, and therefore fill a basin or trough-shaped hollow. The "clay-with-flints" is also well shown here (see p. 66).

At Bennet's End, about a mile southwards, a thickness of 30 or 40 feet of brick-earth is shown at the more northerly brickyard. The earth is mottled bluish-grey scarlet and brown, in some parts very light-coloured, in others very bright, and it contains pebbles and flints. "From 50 to 70 feet of brick-earth have been found here above the

"Chalk."* It spreads eastwards over Leverstock Green, and thence southwards; and in the road-cutting just south of where Hagdale Lane turns off, there are blocks of pudding-stone and paramondra-flints in pebbly brick-earth. At Sheppeys, north of Abbot's Langley, there is a brickyard in which chalk is also got.

"There is brick-earth at the eastern part of Gorhambury Park,"* and also at Saint Albans.

Besides the above-described deposit on the chalk country "there is "a pebbly brick-earth on the London Clay in many places: thus, near "Bentley, W. of Stanmore, there is brick-earth, 12 feet thick, not so "sandy as that of the Thames Valley, and which burns to a red "brick."*

With the gravel of Finchley and Muswell Hill there is sometimes a bed of loam (see p. 71).

On the southern side of the Thames between Great Marlow and Maidenhead there is brick-earth along the valley that runs from Park Corner by the west of Cookham Dean Common and Cookham Dean, and south of Winter Hill. At the first place there are pits showing in parts 10 or 12 feet of brown loam, with thin layers of flint-pebbles and subangular flints. I am not sure but that this may belong rather to the valley brick-earth.

High-level Gravel.

By the above name I understand those gravels that occur on the higher grounds, and are distinct from and older than those that are found in the bottoms and on the flanks of the valleys; having been deposited, to a great extent at least, before the formation of those valleys, which have been cut through them. The term has always been understood in this sense by the Geological Survey; but Mr. Prestwich has lately used it for the high terraces of the "Valley-gravel."† It is here convenient to keep the term for the real high-level drift alone, which indeed could hardly have any other name, and to use, as Mr. Prestwich did formerly, the name "Valley-gravel" for those deposits that occur only along valleys, whether as "Low-level Gravel" in the bottoms, or as "Terrace-gravel" on the flanks. In a later paper.‡ Mr. Prestwich makes use of the longer name "High-level Valley-gravel" for what will here be treated of as "Terrace-gravel."

The "High-level Gravel" of Mr. Prestwich does not really occur at the higher levels of a district; but only high up the sides of valleys: thus the highest gravel-terrace near Maidenhead and Cookham (see p. 82) would be classed by him as "High-level;" whereas I use that name for the far higher deposit on the tops of Bowsey and Ashley Hills, to the west (see p. 69), which has no connexion with the Thames Valley.

For convenience sake I describe this under two heads, according as it consists for the most part of flint-pebbles or angular flints. I cannot pretend however to draw a sharp line between the two, and I must state that I am very likely to have classed some of the gravel wrongly, as my own notes and those of my colleague the late Mr. R. Trench sometimes only record the occurrence of gravel, without stating its composition in detail.

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* From Mr. Trench's Note-book.

† Proc. Roy. Soc. for March 27, 1862.

‡ Journ. Geol. Soc. vol. xix. p. 497.

Pebble-Gravel.

I will first treat of the gravel wholly, or for the greater part, made up of flint-pebbles, which however had their rounded waterworn form before the time of the deposition of the gravel, having been indeed derived from the older Tertiary beds.

On the hill-top just above Luxter's at the western edge of the map, a mile and a half south of Turville, there are two small hillocks of flint-pebbles of various sizes in a loamy matrix. All around is chalk, almost bare, or covered with a little of the usual stiff brown clay-with flints.

At Chequer Farm, north of Turville, the highest part of the hill is of gravel, chiefly of flint-pebbles, the greatest depth of which I was told was 16 feet. At Cadmore End there is more of the same, with a little sand, and perhaps also on the higher parts of the Lane End Tertiary outlier (see p. 70).

On the tops of Ashley and Bowsey Hills, the highest parts of the large Tertiary outlier west of Maidenhead (pp. 42, 53), there is a sandy gravel, consisting of flint-pebbles, a few subangular flints, and here and there quartz-pebbles.

In the gravel on the hills bounding the valley of the Gade near King's Langley there are many pebbles, not only of flint, but also of quartz and quartz-rock (derived from older rocks).

On the northern flank of the hill a little north of Woodcock Hill Kiln near Rickmansworth, and below the Tertiary escarpment, there is a pit about 12 feet deep, in an irregular deposit of sand and gravel: the former at top and with layers of gravel in it; the latter composed chiefly of flint-pebbles, but also with angular flints and a few quartz-pebbles and pieces of iron-sandstone, and containing some small masses of the clayey greensand and green-coated flints of the "bottom-bed" of the Reading Beds. This gravel forms a fairly-marked hillock. In some chalk-wells in the field just north of the kiln I saw some thickness of pebble-gravel lying irregularly on the Chalk.

At Batchworth Heath, and in the neighbouring part of Moor Park, there is some sand and gravel.

In the gravel-pit between Radlets and Batler's Green, east of Aldenham (see p. 19), there is a thickness of six or seven feet of loam, with pebbles of flint, quartz and quartzite, in parts a regular gravel and more sandy; and in another pit about half a mile S.S.W. of Newland the gravel, of like pebbles and also subangular flints, is 12 feet thick, the lower part being lighter in colour and more sandy.

Over the London Clay there is in many places a pebble-gravel. "At "Stanmore Hill a drift of pebbles in sand and loam spreads over the "whole of the hill-top. On the hills around Berkhamstead and "Bayford, at the N.E. corner of the district, there is a gravel of pebbles "in a coarse sandy matrix."*

On the London Clay of Hatfield Park is a gravel composed mainly of pebbles (see p. 22), and a pit at a lower level on the south, at the corner of the lane N.W. of Foxes, shows a gravel of flint-pebbles, subangular flints, and quartz-pebbles, perhaps of the same age, but possibly a valley-gravel. At Potters Bar there is also gravel.

At Hendon there is pebble-gravel on the hill-top, and some, of a fine nature, is found in places on the Bagshot outlier at Hampstead.

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* From Mr. Trench's Note-book.

Angular Gravel.

Under this head I include all gravel that is for the greater part composed of flints only partly worn and not brought to the state of pebbles. All the gravels of our district I believe contain flint-pebbles, but in some cases these are greatly outnumbered by the subangular flints. This high-level gravel is hardly to be distinguished from the lower beds of the Thames Valley, &c.; so that indeed I have often been led to think that in many cases the former may perhaps be simply an older terrace of the latter: it is at any rate noteworthy that on the high grounds at a distance from the greater rivers of the district, the Thames and the Colne, gravel is comparatively rare; whilst on great part of those bordering on the valleys of those two rivers it is abundant.

On the Lane End Tertiary outlier (No. 2, p. 31) there is gravel on the south of Cadmore End Common, on the top of the hill west of Lane End and on Park Hill. I have no note as to whether this is mainly of pebbles or of subangular flints, but I think of the latter.

On the hills south of Loudwater there is much gravel, alike over the Chalk and the outliers of the Reading Beds; and also on the other side of the stream, of the same name, northwards towards Penn.

N., S., and E. of Beaconsfield nearly the whole of the high ground is capped by gravel, so much so that the Tertiary beds are rarely to be seen. Sections of the former have already been noted at pp. 14, 15, and 36, and there are others. "The cutting at the 25th milestone, on the high " road west of Beaconsfield, shows the Chalk capped by brick-earth, " clay, sand, and gravel; and in a chalk-pit close to Davenies, north of the " same town, gravel and sand rest on an uneven surface of the Chalk."* Along the road down hill from Starveall towards Woodlands, south of Beaconsfield, gravel with sand is shown in the cutting, and a chalk-well near the first place proved that there was 15 feet of it over the Reading Beds. There are many pits thence eastwards to the Colne, the high-level gravel almost joining on to the high terrace-gravel. " At West " End, about a mile north of Stoke Poges, there is a pit showing about " 15 feet of brick-earth, with layers of small flints and a thin band of " black ironstone, capped by gravel."* (May not this belong to the terrace-deposits ?)

In the district between the Misbourn (below Amersham), the Chess, and the Colne there is much gravel, spreading over, and hiding the boundaries of, the outliers of the Reading Beds (see pp. 37, 38) and also over great part of the Chalk hills, as from Cheneys to Chorley Wood Common.

Between the Chess below Cheneys and the Gade below Nash Mill the high grounds are for the most part capped with gravel, towards the latter river very pebbly.

On the hills south and east of Berkhampstead there is a little; and on the other side of the Colne at Bedmont and thence towards St. Albans, east of which last place there is more.

About half a mile W.S.W. of the house at Porters, near Shenley, are some pits, eight or 10 feet deep and 15 or 20 feet above the brook, in coarse brown gravel, of subangular flints and flint-pebbles; and there is also gravel on the top of Shenley Hill.

At Hadley and Barnet, and thence some way along the ridge westward, the London Clay is capped by gravel, and there is more of the same near Finchley and Muswell Hill; but this should perhaps be classed with the pebble-gravel. Mr. E. Spencer has made the following remarks on the gravel-drift here : “The district occupied by this deposit extends from “ Muswell Hill to Finchley Common, a distance of about three “ quarters of a mile, its breadth is about 150 yards, and its average “ thickness is from 15 to 20 feet . . . . . immediately beneath “ the vegetable soil is a bed about 14 feet thick, consisting of marl and “ waterworn fragments of granite, porphyry, micaceous sandstone, “ mountain limestone, coal, lias, oolite, and chalk, with many of the “ characteristic fossils of these formations. The most abundant pebbles “ are lias and chalk ; the latter being in so great quantity as to give “ the whole accumulation a chalky character. . . This bed is separated by a well-defined line from another of red gravel, about six feet “ thick, resting upon London Clay. It is composed of rounded chalk-“ flints and sand, Saurian vertebræ—(from the Lias ?)—are occasionally “ found in it.”* *The upper bed would seem to be a true northern drift, and it is to be remarked that the pebble-gravel underlies it and is therefore older.* In the collection of Mr. Wetherell, of Highgate, there is a great number of liassic, oolitic, chalk, and other fossils from this drift, many in a very good state of preservation, and amongst other things is a piece of the so-called “red chalk.”† A M.S. section of Mr. Wetherell's shows the following order of the beds at the Muswell Hill gravel-pit, now filled up :—

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* From Mr. Polwhele's Note-book.

	ft.
Boulder-deposit with fossils of various formations, lying irregularly on the bed below, and sometimes filling pipes that extend through the latter - - - - - - - - -	15 to 20
Laminated brick-earth - - - - - -	3 to 4
Gravel. (Thickness and composition not given. See above.)	
London Clay.	

S.E. of Southgate there is gravel, not much higher than and much like the neighbouring gravel of the Lea. It may perhaps therefore be a higher terrace of the latter. It has been much worked west of Hazlewood, and may be seen in the large pit there. At Bush Hill, south of Enfield, there is fine sandy gravel and sand.

South of the Thames there is gravel, much like that of the lower levels, on the high grounds of Richmond Park, Putney Heath, and Wimbledon Common.

GREYWETHERS AND PUDDING-STONES.

Before describing the lower-level drifts it will be as well to notice the frequent occurrence of blocks of hard sandstone and conglomerate on the surface of the Chalk and Tertiary districts.

I agree with Mr. Prestwich, who has treated of the origin of these blocks in great detail,‡ that in this district they have been derived in great part from the Woolwich and Reading Beds ; although I have been led to think that at the western end of the London Basin, where they are present in greater number, their origin may be traced to the Bagshot Sands.§

Sandstone however is rarely to be seen in place in the Reading Beds, and I know of but two places in our district where it has been observed —near Chesham and Amersham (see pp. 37, 39)—and in both cases the bed is too thin to have yielded any of the large blocks so often found. Near Aldenham, however, there seems to be a large mass of hard jointed pudding-stone in place (see p. 19).

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* Proc. Geol. Soc. vol. ii. p. 181.

† This peculiar bed is all that separates the Chalk from the ferruginous sands of the Lower Greensand at Hunstanton Cliff, Norfolk, where it is but four or five feet thick. It has never been found *in place* in or near our district.

‡ Journ. Geol. Soc. vol. x. pp. 123 to 130.

§ Journ. Geol. Soc. vol. xviii. p. 271.

Mr. Prestwich has noted the fact that it is in Hertfordshire, where the sands of the Reading Beds are often charged with flint-pebbles, that the blocks of conglomerate are most common. Hence the name "Hertfordshire pudding-stone."

It is not unlikely, however, that even in this more central part of the London Basin other formations have also yielded greywethers. The basement-bed of the London Clay often contains a thin bed of sandstone; mostly however with fossils, which, on the contrary, are not found in the greywethers; and in the Wargrave outlier I saw a bed that might well have been the origin of some of the smaller blocks.

I have elsewhere drawn attention to the fact that greywethers are found over the London Clay country, and far from the outcrop of the Reading Beds, which would accord with their derivation from a formation above rather than from one below the London Clay. I am led to think therefore that these loose blocks may have come from various beds, and that in this district their origin may be traced not only to the Reading Beds, but also to the basement-bed of the London Clay and to the Bagshot Sands.

As a rule these stones show no sign of having been carried any distance, and it would seem that they have been quietly let down during the slow denudation and removal of the softer materials of the beds of which they once formed part. The great number found in the brick-earth on the Chalk near Wycombe (see p. 66) agrees with this. Speaking of this part, Messrs. Conybeare and Phillips say: "Large "blocks of a coarse variety of pudding-stone are not uncommon on "the surface of the Chalk at Bradenham."*

The pudding-stones consist merely of flint-pebbles, and sometimes a few subangular flints, in a matrix of greywether-sandstone. They are often remarkable for their even jointing, the joint-lines running indifferently through matrix and pebbles, and giving a flat face. In former times "querns" or millstones were made from them; the unequal wearing away of the harder pebbles and the softer matrix well fitting them for that use. One of these querns may be seen in the Museum at Jermyn Street, where there are also specimens of the sandstone and conglomerate.†

CHAPTER IX.—POST-PLIOCENE SERIES (*continued*).

VALLEY GRAVEL AND BRICK-EARTH.

Range.

Besides the gravel and brick-earth that occur on the high grounds, beds, of a later age, are found along the course of the river-valleys, not always, however, in their lowest parts only (low-level gravel), but often reaching some way up their flanks, and sometimes even capping the tops of the low hills bounding them (terrace-gravel).‡

Alluvium, brick-earth, and gravel are one or more present in the valleys of the Thames, and its tributaries. The first has everywhere been mapped by the Geological Survey, and along the valleys of the Thames and the Wandle, and the lower parts of those of the Loddon and Colne, the last two have been also; but not along the other streams. The reason of this is that it was not until the mapping of this district was all but finished that it was decided that the low-level gravel, &c. should in future be coloured on the Geological Survey Map, and while those deposits took up so large a space in the Thames Valley as to make it needful to map them, it was not thought worth while again to go over a large tract where they cover a much less space, and are of much less importance, but would have taken a long time to survey.

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* "Outlines of the Geology of England and Wales" (London, 1822), p. 50.

† See the "Catalogue of Rock Specimens," 3rd edit. p. 163.

‡ For the sense in which these names are here used, see p. 68.

The importance of the Gravel and Brick-earth of the Thames Valley may be judged of by the fact that they spread from a line through Langley Park, Hillingdon, Hayes, and Ealing right to the southern edge of the district, and into that to the south, and for some miles both east and west of this part they have a breadth of four miles or more. In the chalk-country north and west of Maidenhead their breadth is much less, from three quarters of a mile to two miles.

Structure.

The low-level is so much like some of the high-level gravel that both my colleague Mr. Polwhele and myself often found it so difficult to distinguish between them that we could not help thinking that much of the latter was nothing but a very high terrace of the former. The best description that I can give is in the words of Mr. Prestwich :—

" The great bulk of this gravel is composed of subangular chalk-flints, derived, it may be presumed, from the destruction of portions of the adjacent chalk-surface : whilst, as subordinate materials, we find a considerable number of perfectly rolled and round flint-pebbles, derived directly, not from the Chalk, but from the Lower Tertiary strata and from the Bagshot Sands, also a not inconsiderable number of hard quartzose sandstone-pebbles, pebbles of white quartz, slate, and other older rocks—all perfectly rounded—and these again derived, not directly from the rocks to which they originally belonged, but, as far as I can judge, all, without exception, from the conglomerates of the New Red Sandstone of Worcestershire and Warwickshire. A singular feature of this gravel is, that although the transport of this débris of the New Red Sandstone must have passed over the wide band of the Oolites of the midland counties, yet but extremely few traces of these rocks are to be found. Of the Lower Greensand and sand of the Portland Series a number of the small black pebbles belonging to those beds are met with, but rolled Oolitic fragments are very scarce. . . . . . When this gravel reposes on the Chalk it is generally mixed at its base with a large proportion of chalk-rubble, which sometimes is concreted, and forms a thin solid base or pan to the gravel." *

Masses are sometimes hardened into a sort of conglomerate by oxide of iron, and in the chalk district pieces of chalk often occur throughout the gravel, sometimes in great abundance. This deposit is sandy, and often contains beds of sand.

The brick-earth overlies the gravel, but is not always present ; it is a brown sandy clay, or loam, very valuable, not only for brick-making, but also for the fine soil that it affords to the market-gardener.

The gravel is rarely more than 20 feet thick. The brick-earth is generally less in this district, but sometimes more.

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* Journ. Geol. Soc. vol. xii. p. 131.

Lie.

These valley-beds, like the other surface-deposits, of course lie on formations of all ages—in this district from the Chalk to the London Clay. They often mount up the sides of the valleys by a succession of steps, or "terraces," but sometimes lie evenly on the slopes. Each terrace forms a more or less flat tract, often cut through by valleys deeply enough to lay bare the beds below the gravel.

I found that the mapping of these beds was made the more difficult by the different ways in which they ended off against the older formations. These ways, which are at least three in number, and one of them has many varieties, are shown in Figs. 8 to 11. Of course they pass into one another, so that one cannot always be precise. In Fig. 8 the gravel forms the higher ground, and ends off on the downward slope. This form, of course, occurs with high terraces only. I believe that it is nowhere to be found in the chalk-district, except perhaps at Boyne Hill (W. of Maidenhead); but it may be seen just within the boundary of the Tertiary-country, near Ruscomb, and west of Bray Wick. It occurs on the north of Uxbridge, Hillingdon, and Hayes, at Notting Hill, from Highbury to Stoke Newington, at Wandsworth Common, on the east of Clapham Common, and, of course, wherever a valley cuts through the gravel to the beds beneath. In Fig. 9 the gravel is at the base of the hill, and may either end off at the base or creep some way up the slope. This is the general form along the valley of the Thames from Twyford to Maidenhead, the gravel reaching far up the hill-sides from Great Marlow eastwards to Well End. This form likewise occurs from the north of Farnham Royal to the Colne, from Windsor to Egham, from Hanwell to Wormwood Scrubs, on the south of Richmond, from that place to Wandsworth (excepting where changed by the denudation of the brook near East Sheen, see p. 90), along the boundary of the lower terrace from Tooting to Wandsworth and of the higher at Streatham Common, and from Brixton to Camberwell. Fig. 10 is the passage-form between figs. 8 and 9, in which the gravel occurs on one side of a valley and not on the other, or breaks the continuity of a long

Ending off of the Valley-gravel.

Fig. 8.

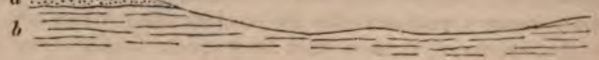


Fig. 9.

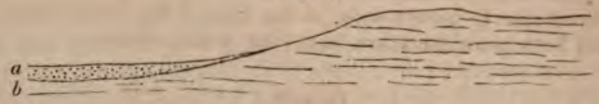


Fig. 10.

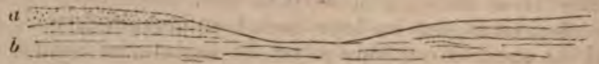
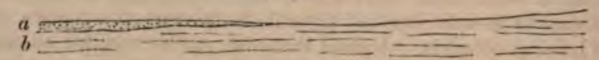


Fig. 11.



(*a*) Gravel. (*b*) Underlying Beds.

slope; in the latter case the right-hand slope continues upwards as in fig. 9. This occurs between Wargrave and Twyford, and between Cookham and Maidenhead, where the slight rise of the highest terrace breaks the even slope of the chalk-hills (see fig. 13, p. 83). As this is a passage-form it may be looked for between the places where the first two forms respectively occur. In fig. 11 the gravel gradually thins off in a flat, and this is naturally the most difficult boundary to find out, as it makes no feature at the surface. It occurs in the valley of the Loddon, S. and N.E. of Hurst, and in the Thames Valley from the south of Bray to Windsor, at the southern end of Regent's Park, and thence a short way eastwards; but nowhere in the chalk-district, owing to the comparative hardness of the Chalk.

It must not be thought that the present boundary of the valley-beds is always their original one, and shows the whole extent of surface over which they have spread. I have already noticed the fact of their being often worn through by side-valleys, along the lower part of which the underlying beds are thereby laid bare; but besides this there has been another and greater denudation, for it is clear that where the gravel now ends off, as in fig. 8, it must once have spread further: one cannot imagine a deposit from water confined within more or less narrow limits, by the rising ground on either side of a valley, to end off in this way; it must clearly have spread to the base of the bounding hills, and the present form must therefore be owing to denudation.

Origin.

As to how these valley-beds were formed, there have been many opinions. Sea, river, and ice have each been brought forward as their cause, and the question can hardly yet be said to be settled, though I believe that nearly all geologists are now agreed in looking on them as the result of some sort of river-action. In treating of so difficult a matter I think it best to confine myself to giving the views of older and more tried geologists. I shall therefore quote various authors who have studied these beds, and shall then give a detailed description of the gravels, &c. as they occur in this district, trusting that my facts may be of use in other hands, and may throw some fresh light on the subject.

Prof. Morris says:—"From the general features, both physical and "fossil, of this deposit [near Brentford] . . . . I am inclined to con-"sider it as resulting from fluviatile action, and that at a period when a "river, far more deep and extensive than the present stream [the "Thames], flowed along the valley. Even allowing the base of the "deposit to be level with high-water, a river of considerable depth "must have existed, to have accumulated and arranged twenty feet "of solid materials, and that not in a very violent manner, for "scarcely any of the bones exhibit the least trace of attrition, most of "them being perfect and many belonging to the same individual; thus "rendering it nearly certain that they could not have been drifted "from any great distance, but were probably the remains of those "animals which lived and died not far from the banks of that stream, "where they subsequently became entombed in the same deposit with "the fluviatile mollusca . . . . it is generally along those valleys "where the present drainage of the country is effected that we find the "most extensive deposits of mammalian bones and recent shells; and "consequently very little alteration can have taken place as regards "the physical configuration of the country since the period of their

" deposition."* The section which called forth these remarks, and the list of the bones and shells found, are noted at p. 87.

It has been thought that for the rivers to have been larger than at present the land must have been lower; but Mr. Godwin-Austen combats this view as follows:—" Along every valley through which a river " takes its course alluvia [that is, river-deposits of any sort, including " gravel, &c.] are to be found at elevations such as the existing streams " never attain. . . . . . . The volume of the rivers of a district " depends directly on the amount of moisture precipitated over it, and " this depends on its elevation above the sea; so that to depress any " given area will not tend to increase its rivers. . . . . . The " conditions which alone will account for these appearances are " obvious—the country, instead of having been placed at a lower level " at the period of these broad alluvia, had a much greater elevation " above the sea. . . . . . This condition is applicable to every " considerable river-course in the island, along every one of which we " can find indications of the larger dimensions of the former rivers. " The Thames and the Severn are striking examples."†

Mr. Prestwich, in his paper quoted at p. 85, remarks the unworn character of the bones from the gravel near Maidenhead, and adds:— " Nor does the gravel itself afford any evidence of long-continued " movement or of much wear. If we eliminate from it the flint-pebbles " derived from the Tertiary beds and the pebbles of the older rocks " derived from the New Red Sandstone, we have a residue of sub- " angular flints which exhibit extremely little wear—nothing like that " which would result from long-continued river or shore-action—and it " is necessarily this residue which gives us the true measure of wear " and tear which the mass has undergone."

For a general and popular account of the gravels near London I refer the reader to Mr. Prestwich's " Ground Beneath Us," where he remarks that " the gravel of Clapham and London consists essentially of the " debris of rocks, transported northward probably from the hills of " Surrey and Sussex, and over distances of not less than from six to " 20 miles. There is, however, a certain amount of conflicting " evidence."

The following remarks are taken from a later paper by Mr. Prestwich, written since the notice of geologists was drawn to the occurrence of flint-implements (see p. 79) in beds of this age.

" It is probable that subsequently to that phase of the Glacial period " marked by the Boulder Clay, the area of dry land became more ex- " tended, and on it there lived the ***Elephas primigenius*** and ***E. antiquus***, " ***Rhinoceros tichorhinus***, ***Hyæna spelæa***, with species of ***Deer***, ***Horse***, " and other animals, mostly of extinct, but some of species not to be " distinguished from the recent; whilst the waters of both sea and " land were tenanted almost exclusively by shells of recent species still " common in this and adjacent countries. [Mr. Prestwich refers to parts " of France; but his remarks apply to England equally well.] The " remains of this old surface we find in deposits, which everywhere " contain a similar group of organic remains, and occur mostly in old " valleys or at moderate elevations. They are never overlaid by other " fossiliferous deposits, and I believe them all to belong to a state of " things which immediately preceded the present order. One feature

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* Journ. Geol. Soc. vol. vi. pp. 203–4.

† Journ. Geol. Soc. vol. vi. p. 93.

" of these deposits is, that although closely related to the present con-
" figuration of the surface, yet they are always more or less independent
" of it. They are often near present lines of drainage, yet could not,
" as a whole, possibly have been formed under their operation . . . .
" lower-level deposits are, although not to the same degree [as those
" of the higher level], quite beyond the agency of present river action,
" and are independent of recent changes. It is probable that the
" various beds, although on these different levels, belong to the same
" general period, and may be nearly synchronous."*

The paper I have now to notice is as yet published only in abstract.† In it Mr. Prestwich notes the following facts and opinions :—

Both Terrace and Low Level gravels " consist of débris derived from " rocks in the valleys through which the present rivers or their tribu" taries flow, and they both occasionally contain organic remains ; both " are, in fact, related to former plains and present valleys."

" Each large hydrographical basin, although the boundaries may not " be marked by any important elevation, has its own exclusive drift, " and in no case is there a mixture of the transported materials of the " separate basins ;" but these valley-drifts, which contain the remains of large extinct mammals, have not " in any way depended on or resulted " from any general cataclysm destroying these creatures nearly simul" taneously over wide continents, and entombing their remains in the " sand, gravel, and shingle of the valleys, and in the earth of the " caverns ;" nor were the valleys worn out before the spread of the gravels.

" That the formation of the higher gravels can be owing to the action " of the present rivers is clearly impossible under existing circum" stances ;" for they are far above the level of the rivers at the highest floods.

" Some of the Low-level gravel is constant ;" not so the terrace-gravel, the isolated patches of which, however, must have once been connected.

" That the transport of this drift could have been caused by the " bursting of lakes, by the sudden melting of the glaciers and snow of " mountain-chains, or by the transient passage of a body of water over " the land, is not possible, because the spread of the débris would have " been more general, would have held its course more irrespective of " the existing watersheds, and would have shown an amount of wear in " proportion to the distance travelled ; whereas in each basin the débris " is local, however low the watershed." . . .

The terrace-gravels " are the result of river-action which took place " at a period before the excavation (? deepening) of the present river" valleys."

The materials of the gravel have often been brought from some distance, and there are often large blocks of hard rocks. The bedding is commonly confused and contorted. " The only adequate cause to pro" duce many of these effects is river-ice, the transporting power of which " is well known."

That the rivers were larger and more rapid than now " is evident from " the great quantity of débris, the prevalence of gravels, the coarseness " of the sands, and the general absence of mud-sediments."

In the terrace-gravels shells are for the most part scarce, or wanting ; all are of living species, and nearly all live in the same district. The

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* Phil. Trans. for 1860, pp. 302–3.

† Proc. Roy. Soc. for March 27, 1862.

Mammals seem to show that the climate was colder than at present. " If we had to depend only upon the organic remains for decisive " evidence of the nature of the climate . . . . we should at present " fail to arrive at any safe and exact conclusion. If however these in- " dications are taken in conjunction with the physical features, the " conjoint evidence has weight and more preciseness."

The flint-implements in the Terrace-gravel "are most common where " the evidence of ice-action is the greatest ;" and some therefore "may " have been used as ice-chisels."

With regard to the Low-level gravels the melting of winter-snows, &c. "combined possibly with a larger rainfall, must have afforded to the " old rivers . . a volume of water far exceeding any present supply, " and giving them more of a torrential character." . .

"Other forces, however, besides an increase in the water-power, seem " required to account for the excavation of the great valleys . . . cold " and ground-ice have performed a very important part in the operation " . . . Another agent would co-operate with the last ; this is the " freezing of the ground and the rending of the rocks by frost."

Mr. Prestwich " doubts whether, without an uplifting of the land, " the effects in question could have been produced . . . The effect " of this slow elevation would be to increase the velocity and erosive " power of the rivers. . . According to variability in the rate of " elevation, to intervals of repose, or to deflections in the current, and " (changes in the) velocity of the river, there may exist intermediate " levels or terraces of gravel, and variations in the inclination of the " slopes." In this district there are often three well-marked levels of gravel, &c.

The shells of the Low-level gravel, except the *Corbicula fluminalis* (not found in this district), " are all common living species of England " and France." The Mammalia are few in number, and " as with the " Mollusca, most of the species are common to the two series." The fauna points to a somewhat colder climate than our own.

The low-level gravel does not show the marked signs of ice-action seen in the terrace-gravel. " From this fact and the general balance " of evidence furnished by the fauna," one is led to infer " a gradual " amelioration in the temperature, ending in the present climatal " conditions."

" Flint-implements are nowhere so abundant. . . ' Flakes,' or " flint-knives, are abundant [not in our district, however; see p. 79.] . " admitting the climate to have become less severe during the low- " level gravel period, it would follow that the necessity of having " strong ice-chisels would have diminished."

Mr. Prestwich notices " the remarkable uninterrupted succession of " life from the Pleistocene period under review to the present time— " a succession so large and important that it is not possible to imagine " the occurrence of any intervening catastrophe of such a nature as to " destroy the life of the period. There are difficulties in the problem, " especially the disappearance of the larger animals; but the remarkable " and convincing feature in the case is the transmission to our time of " so large a proportion of the small and delicate land and freshwater " shells, which even now follow almost precisely the same law in their " distribution as they did at these latest geological periods."*

For a refutation of the doctrine held by many French geologists that the valley-gravels were formed by some imaginary " wave of translation," or other sudden catastrophe, I refer the reader to a lately-published paper by Mr. Prestwich, from which I take the following extracts:

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* Proc. Roy. Soc. for March 27, 1862.

"I have attributed the formation of these beds to river-action con-" tinued through a long period of time, and gradually excavating the " valley from the level of the high-level [terrace] gravels to that of " the low-level gravels."

A section of the Somme Valley, as a type of such valleys, at the period of the terrace-gravel, would show "a shallow and broad river, " with numerous, generally dry, shoals and shingle-banks, but during " floods, arising from the melting of the winter-snows, and a greater " rainfall than at the present day, rising to a height of 40 to 50 feet above " its ordinary level, flooding the adjacent country, and depositing, out " of the course of the main current, the fine silt now forming the Loess " [brick-earth]. . . As the valley was by degrees excavated, such " portions of the old river-bed as escaped denudation emerged gra-" dually from the level, first of the river, and later of the river-" floods."*

The loam or brick-earth that so often covers the gravel Mr. Prestwich regards as a deposit from flood-waters. Mr. Godwin-Austen, speaking of drift deposits on the Sussex coasts, says:—"With reference to the " conditions under which the brick-earth has been formed, it may be " stated generally that it is a subaërial deposit. In every instance, in " every country, it partakes of the nature of strata immediately conti-" guous. . . Its most usual character is that of the wash of a ter-" restrial surface under a far greater amount of annual rainfall than " we have at present. . . In any speculations respecting the origin " and circumstances of the brick-earth deposit, it must be constantly " kept in mind that the present physical features are not those of the " period when the brick-earth was deposited."† In parts of Kent, where there is a large area of sandy Lower Tertiary Beds, there is often some thickness of mere "rainwash brick-earth."

Flint Implements.

The gravel and brick-earth of the Thames Valley, &c. is, both in structure and position, like those deposits in the valley of the Somme, so noted for the finding in them of flint-implements that were clearly made by the hand of man, together with the remains of extinct Mammalia, and for a detailed account of which I refer the reader to the papers of Mr. Prestwich‡ and Mr. Evans;§ the former of whom has also drawn attention to the kinship of the French and English valley-beds, and has pointed out many gravel-sections in the district of which this memoir treats, where like implements may be expected to be found.‖

As yet I believe that but three implements have been found in this district, two merely lying on the surface however, and the third found so long ago (some 150 years), and its finding being so shortly recorded, that one cannot take it as evidence. It was found near Gray's Inn Lane, is now in the British Museum, and is figured in the former of Mr. Evans'

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[*] Journ. Geol. Soc. vol. xix. pp. 500 and 501.

[†] Journ. Geol. Soc. vol. xiii. pp. 63 and 64.

[‡] Phil. Trans. for 1860, p. 277.

[§] Archæologia, vol. xxxviii. p. 280, and vol. xxxix. p. 57.

[‖] Journ. Geol. Soc. vol. xvii. p. 362. I would add to the sections to which Mr. Prestwich here draws attention all large pits whatsoever in the valley-beds, though surface specimens are more likely to be found than any in place in the gravel.

papers. The others were both found by Mr. Evans himself, one in 1861 in a field near Bedmont, north of Abbot's Langley (Herts), the second in 1862.

With regard to the use to which these implements may have been put, see p. 78.

CHAPTER X.—POST-PLIOCENE SERIES (*continued*).

VALLEY DRIFTS—(*Detailed Account*).

I shall first describe those districts where these beds are shown on the map, that is, along the Valley of the Thames, with small parts of those of the Loddon, Colne, and Wandle. The same colour has been used for Alluvium, Brick-earth, and Gravel, the last two being marked by stippling, and generally, though not always, divided by an engraved line from the first, but never from each other. All three have a different index-mark.

It will make matters much clearer if the deposits of this large valley are treated of in different local divisions, as was done with the Tertiary outliers, starting from the west, as before.

A.—On both Sides of the Thames above Cookham.

The boundary of the tract mapped as gravel between the Thames and the Loddon, south of Shiplake, is quite arbitrary, a higher terrace spreading some distance to the south and south-west, but which could not have been mapped without carrying the survey back some way into the Sheet to the west (13).

On the eastern side of the Loddon for two miles or so south of Twyford there is some breadth of gravel, forming a flat about three-quarters of a mile broad, with a doubtful boundary on the south, where the London Clay is almost as flat as the gravel. At Hurst the former rises slightly from beneath the latter, but between that place and Haines Hill it is again flat.

The gravel near Ruscomb belongs to a higher terrace, extending from the east of Stanlake to within a mile of Wargrave. The railway-cutting and a large pit on its northern side give sections (see p. 12).

On the other side of the Thames, from Shiplake to Medmenham, the gravel rises gently from the river-flat, its boundary for the most part following the contour of the ground, and nowhere a mile from the river (and partly in Sheet 13). The only noteworthy section is at the spot where the "G" of "Oaken Grove," north of Remenham, is engraved on the map, in a pit that shows from 15 to 18 feet of coarse gravel (many very large flints, and pebbles of quartz, quartz-rock, and flint) with enough chalk in it to give it a whitish colour, and here and there to cement masses together: the matrix indeed looks very like a coarse mortar.

A narrow band of coarse gravel, partly covered by alluvium, reaches along the bottom of the Hambledon Valley up to Fingest and Turville.

Going back to the Berkshire side of the Thames, there is a small low strip of gravel at the foot of the high chalk cliff opposite Henley (in Sheet 13). From Remenham to Aston there is more; and whilst the Chalk is at the surface on the southern side of the lane, just above gravel again comes on in the form of two outliers, the remains of a higher terrace, the rest of which has been denuded. There is a gravel-pit by the road east of the church, and a chalk-pit just below. Another larger mass spreads from the river at Culham Court to the cliff-foot at Bisham, its boundary-line gradually rising to a higher level at Hurley Bottom, and then falling eastwards. On the northern side of the high road at the foot of Rose Hill there is a pit, more than eight feet deep, in gravel made up of flints, flint-pebbles, and pieces of chalk, the last in great abundance; and a like chalk-gravel occurs about the oval plantation in the park at Culham Court. On the other side of the road, just west of the Hurley turnpike, a gravel-pit gives a very good and somewhat remarkable section. When I saw it (in August 1860) the greater part was hidden by turf and fallen earth, the eastern end being the clearest and showing the following beds :—

	ft.
Shattered flints (mostly large) and small pieces of chalk, in a sandy matrix ; lenticular masses of light brown sand at one part - -	5 to 6
Buff sand, partly clayey - - - - - - -	6 to 7
Sandy gravel—subangular flints, pebbles of flint quartz and quartz-rock, and pieces of chalk—not gone through - - -	7

In the last bed I found a piece of a large *Ostrea* or *Gryphea* (Oolitic), the only fossil from older beds, excepting those in chalk-flints, that I have found in the valley-deposits of this district. At the western end of the pit this bed is rather thinner and buff sand is shown below it, and at another part there is at the top of the section an earth made of little else than small pieces of chalk. In the chalky gravel that here forms the top bed, as also in that at Rose Hill, there are pipes of a brown clayey earth with flints, most likely a mere soil, or "rain-wash," owing to atmospheric action.

From the sections noticed above it is clear that the gravel between Marlow and Henley is in great part made up from the chalk itself, and not only from the hard flints in that rock, and that this is the case not with the lower part only, but also with the higher.

The Hurley pit has yielded many fine Mammalian remains, which were saved through the care of Mr. Sheldon Wilkinson, of Great Marlow, who gave me the following list of the specimens in his collection, and told me that all of them were found in the gravel at a depth of about 18 feet from the surface.[*]

Bos longifrons, an almost perfect skull and horns.
? *Cervus Tarandus* (Reindeer), horns of
Elephant, teeth and tusk.
Felis spelœa (Cave-tiger), teeth.
Hippopotamus, incisor.
Horse.
Mastodon, parts of tusks.
Rhinoceros.

Again crossing the Thames we find gravel spreading northwards from the river from Hurleyford Grove by the north of Great and Little Marlow to the Loudwater Valley. It may perhaps run further up the valley N.W. of Great Marlow than is shown on the map. From this eastwards to beyond Little Marlow its boundary-line is at a comparatively high level, some way up the flanks of the hills. There are several pits.

B.—On the Right Side of the Thames from Cookham to Egham.

On the Berkshire side, between Cook Marsh and the Great Western Railway near Maidenhead, is a most interesting gravel district; for although of no great breadth compared to the wide-spreading mass further east, yet as the gravel is here underlain by the Chalk, and not, as there, by the softer Tertiary beds, the valleys worn through it are clearer than is the case to the east; moreover the main facts are here brought together into a small space, not scattered over a large one. To make the following remarks more easily understood, a map of the country between Cookham and Maidenhead is given in figure 12. It is from a tracing of my working copy, and therefore on the same scale as the Geological Survey Map; but whereas in the latter the gravel is all mapped as one mass, in this woodcut each terrace is shown. It will be seen that the upper boundary of the gravel is very irregular and winding: this is owing not to the original deposition of the gravel, but to denudation through it to the Chalk beneath; for here the former does not fill the bottoms of the smaller hollows or side-valleys, but on the contrary forms their sides, whilst the latter is found in their lowest

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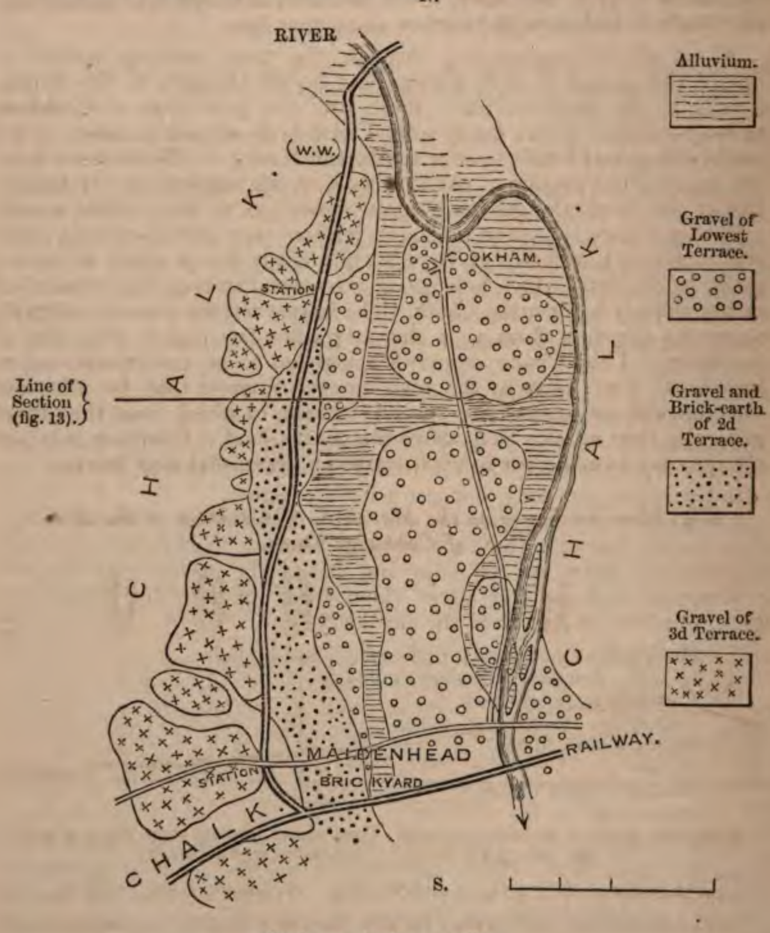
[*] I am sorry to say that since this was written I have heard of Mr. Wilkinson's death and the dispersion of his collection.

Fig. 12.—*Map of the Terraces of Gravel N. of Maidenhead.*

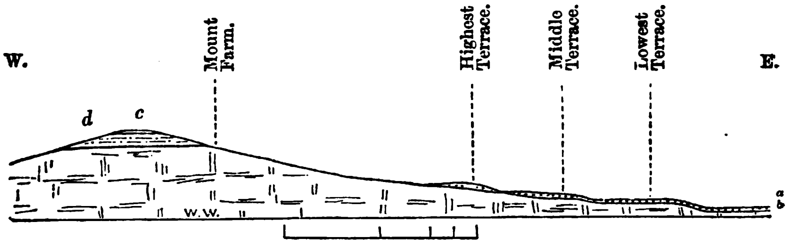


Scale: an inch to a mile.

parts. It will also be seen that these creeks, so to speak, of Chalk do not reach beyond the highest terrace, but are brought to an end at the higher edge of the second terrace by the gravel there falling to a lower level (see fig. 13). In some places the denudation through the gravel of the third terrace has left outliers, surrounded on all sides by the Chalk; and it is not unlikely indeed that the whole of that terrace may be cut off in this manner by a very thin strip of Chalk coming to the surface along the boundary of the second terrace; but as loose matter like gravel is often brought down by rain to a lower level, so as to hide its original boundary, this is doubtful, although it is certain that the Chalk is very near the surface along that line.

Along the railway-cutting through the most northern outlier in fig. 12 the gravel is well shown, and is cut through to the Chalk, except at the southern part; there are pits just west of Cookham railway-station; brown sandy gravel with beds of sand is shown in the road-cutting half a mile to the south, and thence to Maidenhead there are many other sections. At and west of the station on the branch line at that town the gravel is again shown (see p. 45); whilst a little to the east there is a large chalk-pit, without any gravel-capping; and still further a brickyard, giving a section many feet in depth of brown sandy brick-earth, which belongs to the second terrace, and must abut rather sharply against the Chalk. The lowest terrace rises but slightly above the alluvium, forming a flat only a few feet higher than that of the latter. This terrace moreover seems not to be continuous, but to have been worn away by the river in such manner that the alluvium sometimes abuts against the second terrace, in which case the gravel generally rises at once well above the marsh-land. However it is not always easy to make out to what terrace a gravel-flat may belong.

Fig. 13.—*Section from the Marsh S. of Cookham to the Hill S. of Cookham Dean.*



Horizontal Scale, 2 inches to a mile. Vertical Scale, about three times as great (an inch to 880 feet). * Sea-level (approximate).

a Alluvium. *b* Gravel. *c* London Clay. *d* Reading Beds. *e* Chalk.

The woodcutter has failed to show the alluvium above the gravel on the extreme E. of the section.

The section fig. 13, part of the line of which is shown on the map, fig. 12, may help to give an idea of the different terraces. It must be borne in mind that the horizontal scale of the section is twice, and the vertical therefore six times, as large as that of the map: even with this some exaggeration could not be helped. It is carried westwards through the Tertiary outlier near Cookham Dean (No. 43, p. 44).

The third terrace ends off on the west somewhat suddenly, rising very slightly above the Chalk, which shows that the gravel has spread further in that direction, its present boundary being caused by denudation (see p. 75).

In the high terrace (only partly shown in fig. 12) spreading from the railway S.W. of Maidenhead to Shoppenhanger's Farm and the west of Bray Wick, there are many sections. Thence eastwards to Windsor the boundary-line is somewhat doubtful, as the Tertiary beds for the most part do not rise at once from beneath the gravel, but for some distance form a flat continuous with it. Near the main road, however, there are many gravel-pits. The sides of the brook half a mile west of Surly Hall show two or three feet of clay over the gravel; this may be merely the wash of the Tertiary-land on the south, but if there be much of it the boundary-line of the gravel will be all the more doubtful.

From Windsor to Egham the gravel does not seem to rise to any great height above the river, and along the edge of the alluvial flat of Long Mead and Runney Mead there is but a narrow fringe of it. At the lodge by the Victoria Bridge in the Home Park I saw, in February 1858, a little gravel over five or six feet of light-coloured sand. Remains of elephant, ox, and deer have been found "near the new "garden at Frogmore, in a gravel-pit. . . at about the depth of 15 feet "from the surface. The upper soil for about four or five feet is sandy "loam, then there is six or seven feet of red gravel, and three or four "feet of washed gravel (wet gravel ?) in which the bones were found."*

C.—On the North of the Thames from Maidenhead to the Colne.

On the northern side of the Thames east of Maidenhead the gravel and brick-earth take up a very great space, the boundary-line running thence eastwards to the northern part of London. This large tract may be divided into four divisions, by the Colne, the Brent, and the Serpentine.

The boundary-line winds round the hill on which Taplow stands, getting higher and higher in its N.E. course to Poyle and Burnham Grove, from which last place, by the north of Farnham Royal, Stoke Poges, and Wexham, to Iver, on the Colne, it is doubtful. This gravel is here but slightly separated from that of the higher levels of Dropmore, Stoke, and Fulmer Commons, &c. (not coloured on the map) by a narrow outcrop of the Tertiary Beds; indeed I cannot but feel some doubt as to whether the high-level gravel here is not merely a higher terrace of the lower deposit. There is an outlying patch, not shown on the map, on the north of Burnham and Hitcham, that must belong to the latter.

North and east of Burnham the gravel is cut through by the valley along which a small stream flows to Ash Mill, and it is not unlikely that further east other brook-valleys may cut through the gravel to the Tertiary Beds; some must nearly do so at all events.

There are many signs of terraces, but they are not very well marked. I noticed one that seemed to run by the south of Farnham and Stoke churches, and by the north of that of Wexham to the southern end of Langley Park; and another at a lower level, nearly along the high road from Taplow railway-station to Ash Mill, and then on the south of that road to Upton.

On the northern side of the railway, a little east of this station, there is a very large pit in part of which the gravel is cut through to the Chalk. It was here that the Rev. C. Kingsley and Mr. J. Lubbock found the skull of the musk-buffalo (*Bubalus moschatus*) described by Professor Owen.* In his "Note on the Gravel, &c." Mr. Prestwich says that besides this skull "Mr. Lubbock procured a few elephant and "other bones, but in a very imperfect state. They were all found low "down in the gravel—at the point where it becomes mixed with chalk-"rubble, or on the top of the Chalk itself. . . . . The bones, as usual in "such situations, although very friable, are tolerably entire, or if broken "are not worn"† (see also p. 75).

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* The Geologist, vol. iii. (1860), p. 420.

I am not quite prepared to agree with Mr. Prestwich in calling the higher bed of gravel of the section in his paper above quoted "high-level." In that section the southern slope of Taplow Hill is (needfully) much exaggerated, and thereby also the vertical distance between the two beds of gravel. I believe that further east the gravel is continuous, or slopes up, from the level of the large ballast-pit near Taplow station to that of Taplow village, and I therefore think it likely that the high-level gravel of the section may be merely a higher terrace of that at the railway, which latter itself belongs to a terrace many feet above the river. Mr. Prestwich himself says that it is "very similar in many "respects to that in the valley."

Around Burnham, Farnham Royal, and Stoke Poges there are many pits, some large, in the usual flint-gravel, which, rising gradually from the river, must here reach a height of more than 100 feet above it. There are other sections of the gravel from Taplow, by Slough and Upton, towards Colnbrook, and also in the lower gravel-flat of Dorney, Boveney, Eton, Datchet, Horton, Wyrardisbury (or Wraysbury), and Colnbrook. Near Datchet the gravel is often hardened into a sort of breccia by the infiltration of a small quantity of iron.

At the brickyard above the railway, S.S.W. of Burnham, there is light-brown or buff loam (brick-earth), 10 feet thick, above the gravel. There is a great spread of this from Slough towards Wexham and Langley Marsh, indeed eastward to the Colne, and just north of the first place, it is largely worked.

On the western side of the Colne, just above and below Denham, the gravel has been mapped. About a mile south of that village brick-earth is worked.

D.—North of the Thames between the Colne and the Brent.

This is the widest tract of gravel and brick-earth in the whole of the Thames Valley, and there are many small streams flowing through it.

A spur of gravel spreads over Uxbridge Common northwards to Harefield Lodge, and forms the top of the hill. This high terrace may perhaps be an outlier, separated from the lower gravel on the south by denudation through to the underlying London Clay in the higher part of Uxbridge, along a line parallel to, but a little above, the High Street. The gravel has been denuded away along the valley between Uxbridge and Hillingdon, to a point a little south of the road; but it again spreads northwards, over the higher ground, to Little Hillingdon, and thence to the brook at Yedding Green, the boundary-line gradually falling to a lower level. The rectangular area of brick-earth between the last place, West End, and the canal has a doubtful boundary. On the other side of the canal the London Clay rises up from beneath; but further east a spur of gravel reaches northwards to Greenford, and is cut off on the east by the Brent, which river has worn its way through to the London Clay as far south as Hanwell, if not further.

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* Journ. Geol. Soc. vol. xii. p. 124.

† Journ. Geol. Soc. vol. xii. p. 132.

Around Hillingdon and Hayes there is gravel, shown in many pits; south of Uxbridge there is brick-earth as well; and at West Drayton, and thence to Southall, there is a great sheet of the latter, giving rise to many and large brickyards. Near Drayton the brick-earth is not very thick, mostly not more than six feet perhaps; and it has been quite worked out in many places, the gravel below having been thereby laid bare, and the level of the ground evenly lowered over areas of many acres. The shallow cuttings along the canal show both the brick-earth and the underlying gravel.

Between Southall and Hanwell there is a great thickness of gravel, which may be well seen in some large pits where the Great Western Railway crosses the high road, and also in the cutting of the Brentford branch-line. Southwards there is brick-earth at Spring Grove, and still further south gravel only.

At Staines, Hounslow Heath, &c. there is again gravel. There is a pit about a quarter of a mile south of Hanworth church, and gravel is shown in the railway-cutting at Hounslow Station. A fairly-marked terrace rises on the western side of the brook from Isleworth to Twickenham, and thence south towards Maude Cottage. It seems to be a gravel terrace; at Twickenham there is brick-earth on the lower ground at its base.

Whilst this memoir was in the press I visited the works of the new Thames Valley Railway. The long cutting westward of Teddington was not finished, the middle part being untouched. The shallow north-eastern end, about half a mile N.W. of Strawberry Hill, is in gravel; but as the ground rises westward the London Clay rises up from below: it is dark grey, and with an almost continuous bed of septaria. The junction of the clay and the gravel is for the most part even, and only the very topmost part of the clay discoloured brown. The gravel is evenly bedded, and a great quantity of water was thrown out from it by the underlying clay. The south-western end of the cutting is also in gravel, in parts cut through to the London Clay.

On the northern side of the Brent, from the east of Greenford to a little beyond Perivale, there is a gravel-flat about a quarter of a mile broad, the western part separated from the stream by a strip of London Clay from which the gravel has been denuded.

E.—North of the Thames between the Brent and the Serpentine.

From Hanwell to East Acton the gravel ends off at the foot of the London Clay hill; but thence eastwards to Notting Hill the boundary-line of the valley-beds is somewhat doubtful, as the highest gravel terrace is there wanting, and it is the middle terrace of brick-earth that spreads over the London Clay. To make matters worse the brick-earth, generally very sandy, is here not unlike the stiff London Clay; however anyone who has shot at the rifle ranges on Wormwood Scrubs after wet weather will never doubt that both soil and subsoil are of the stiffest clay.

At the top of Notting Hill there is a high terrace of gravel, separated from the lower terrace of Kensington by a narrow strip of London Clay, laid bare by denudation through the gravel from Holland House eastward, above the High Street, to a little west of the Gore—perhaps even further east, as shown in Mr. R. Mylne's map, in which this strip of London Clay is carried on to that just south of the Serpentine. This terrace is the cause of the springs and moist ground in the southern part of Kensington Gardens, where the water is thrown out from the gravel by the underlying stiff clay. At Notting Hill the gravel does not seem to spread far to the north of the Bayswater Road, and it has been denuded through for a short way down the Serpentine valley, there being a very narrow outcropping fringe of London Clay along the western edge of the water in Kensington Gardens. It is this latter formation of course that holds up the water of the Serpentine; and it again comes to the surface at the eastern end of the lake, and separates two terraces of gravel from Hyde Park Corner through the Green Park and on the south of Piccadilly to near Charing Cross, making a slight rise of the ground along that line. The Museum in Jermyn Street, the head-quarters of the Geological Survey, is, I believe, partly on the gravel, of the higher terrace, and partly on the clay. In Mr. Mylne's map the latter is coloured some way up the hollow that runs across Piccadilly: this may be right, but I do not know on what evidence it rests.

Near Hanwell, Ealing, and Acton the gravel is often shown in pits and railway-cuttings; there is also brick-earth, which is worked at Ealing Common.

Near Brentford, Acton, and Chiswick the terrace-structure may be well seen. I have traced the rise of the highest terrace from Drum Lane by a little below Gunnersbury and Acton to East Acton, where this terrace ends off and the next below, chiefly of brick-earth, takes up the whole space between Wormwood Scrubs and the Thames. The rise of the latter terrace I have traced from the river at Kew Bridge by the north of Strand Green, where it is very well marked, to the south of Chiswick House, and thence to the river again at Chiswick.

The space south of this line, that is in the bend of the river between Brentford and Chiswick, belongs to another terrace (the lowest) of gravel, capped by a foot or more of light brown sand.

The second or middle terrace is here the most important, owing to the wide-spread bed of brick-earth above the gravel, and the most interesting, from the fact of mammalian remains having been found in the gravel. The late Mr. J. Trimmer was, I believe, the first to make known this discovery,* and he was followed by my friend and first teacher of geology, Prof. Morris, who has given an account of the beds shown in the cutting of the South Western Railway at Kew Bridge Station and of the fossils found in them.† From this latter paper I have taken not only the list of fossils given further on, but also the following section and remarks, as the cutting must have been much clearer when seen by Prof. Morris than in 1860 (when I surveyed that neighbourhood) although part of it was then being widened:—

	ft.	
Vegetable mould	1	
Brick-earth, fine brownish loam	4	about 20 ft.
Sand, bedded and false-bedded, with a little gravel	6	
Sand with clay and irregular gravel	½	
Ferruginous gravel and sand, with patches of clay	1	
Clayey sand and sandy gravel, with large flints here and there (*Bones* and *Shells*)	1 to 2	
Ferruginous sand and gravel	½	
Light clayey sand and ferruginous gravel with boulders (pebbles?) of quartz, granite, rock with ammonites, &c. (*Bones*)	6 to 7	
London Clay.		

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* "An Account of some Organic Remains found near Brentford," Phil. Trans. 1813, p. 131.

† Journ. Geol. Soc. vol. vi. p. 201. (See also p. 75.)

"The section above given, although differing in minor details, presents similar general characters to those recorded by Mr. Trimmer as occurring in the clay-pits examined by him, one of which is more than a mile distant." It "gives the principal features of the deposit, as exposed in the deepest part of the railway-cutting, which extended for about a third of a mile, and presented great variations in the order and relative thickness of the sands and gravel, which pass into one another in a very irregular manner." Here, as at Hurley and Taplow (see pp. 81, 85), "the bones were most abundant in the lowest stratum." They were of the following species:—

Bison priscus.
Bos longifrons.
Cervus elaphus (Red Deer).
——— *Tarandus* (Reindeer).
Elephas primigenius.
Felis spelæa (Cave Tiger).
Hippopotamus major.
Rhinoceros tichorhinus.

Besides these, shells of the following molluscs were found:—

Bithinia tentaculata, Linn. (= *B. impura*).
Limnæa auricularia, Linn.
——— *stagnalis*, Linn.
Succinea putris, Linn. (= *S. amphibia*).
Valvata piscinalis, Müll.
Anodonta cygnea, Linn. (= *A. anatinus*).
Cyclas cornea, Linn.
Pisidium amnicum, Müll.

At Coles Hole Pottery, just north of Kew Bridge Station, brick-earth and a little gravel and sand are found above the London Clay, which last is worked.

Over the greater part of the tract north of the high road from Turnham Green to between Hammersmith and Kensington the gravel is covered by the usual brown loamy brick-earth, only a few feet thick, so that in many places it has been worked away; however, on both sides of the railway for some way south of Wormwood Scrubs, the brick-earth takes a new character, being a brown clay, rather like the London Clay (see also p. 86), but with lines of "race" and here and there of small flints, and sometimes slightly sandy. At one brickyard I was told that gravel had been found below some 10 or 12 feet of this, but that at another part 30 feet had been sunk through clay alone, the lower part being stiffer and of a more bluish colour (London Clay?—without gravel between it and the brick-earth).

This terrace extends to the Thames at Hammersmith, but there is a thin strip of the lowest terrace (gravel) along the river, from about three-quarters of a mile south of that place by Fulham church to between Parson's Green and Sandy End, where it seems to run as a spur up towards Walham Green, and then to the Thames at Cremorne. Of course this line is that of the rise of the second and principal terrace, which seems again to form the river-bank at Chelsea.

The highest terrace at Notting Hill is gravel. In pits dug for the foundation of a house on the northern side of the Bayswater Road I saw many feet of coarse light-coloured sand.

F.—North of the Thames and East of the Serpentine.

On the northern side of the lake at its eastern end the gravel comes down to the water, as the cutting for the large sewer (main drainage works), but a few yards from the edge, showed a great thickness of gravel. Further west, however, the London Clay comes to the surface for some way up the little hollow, and then, as on the other side of the lake, forms a narrow damp fringe between the gravel and the water to the Bayswater Road. The boundary-line then still follows the course of the brook as far as the Great Western Railway, whence eastwards by Paddington to the southern part of Regent's Park it is doubtful. In Mr. Mylne's map the gravel is coloured farther to the north than on the Survey map, perhaps rightly.

In the excavations for the foundations of the Langham Hotel, Portland Place, below the "made ground" about 15 feet of sand and gravel were dug through. The sand was in excess, and both were bedded and false-bedded. There was much black earth in the sand, and the gravel was at one place quite blackened by it.

In making the tunnel for the Metropolitan (Underground) Railway, a great thickness of gravel was found the whole way from Paddington to Euston Square, showing that the boundary must lie to the north of the Marylebone and Euston Roads. In most parts much water was thrown out from the gravel by the underlying clay, making constant pumping needful. Beyond Euston Square the tunnel is in London Clay, the gravel having been denuded away along the valley of the Fleet (from King's Cross towards Blackfriars Bridge).

On the other side of this valley a bay of London Clay runs some way along and east of the Lower Road, Islington, and a spur of brick-earth, with a doubtful boundary, runs out from Islington over the New Cattle Market. In Mr. Mylne's map the brick-earth and gravel of Islington, &c. is cut off from the main mass, and shown as surrounded on all sides by London Clay. I cannot say that this is not the true state of the case, the ground being covered with houses, but the balance of probabilities seemed to me to be against it. Mr. Mylne also gives the brick-earth of Copenhagen Fields a further range westward than is shown on the Survey map, and this I am more inclined to agree with, as I lately noticed in the collection of Mr. Wetherell of Highgate some bones of *Elephant* and *Hippopotamus*, with which was the following note, written by that gentleman in 1857: "Fragments "of bones . . . . . were found about 15 years since in digging "for a sewer on the side of the road leading from Holloway to Camden "Town, and near Brecknock Crescent. The bed in which they oc-"curred was only a few feet from the surface, and rested on the "London Clay."

From Highbury the boundary-line runs north-eastwards to the edge of the district, the brick-earth and gravel forming the rising ground of Highbury Terrace, Paradise Row, and Stoke Newington. Near Highbury the former is very thick, sometimes nearly 30 feet of it having been found; at one of the brickyards it is capped by a clayey gravel, and underlain by sand and gravel; and at another it is somewhat bedded. There are also brickyards on the northern side of the North London Railway near Newington Station, south of which there is brick-earth, gravel, and sand. The great quantity of the last in this neighbourhood is noteworthy. The brick-earth is here worked away, so that the foundations of the houses (built of the bricks made from it) rest on the gravel below.

In Mr. Wetherell's collection there are some remains of *Elephant* and *Hippopotamus* from Newington, and "in the excavations for build-"ings in many parts of London near the river, animal remains have "been found, as at Waterloo Place."* Mr. Prestwich has described a fossil-bearing bed in the gravel at Hackney, just beyond our district.†

Gravel and sand have been shown by the excavations for sewers, &c. along Tottenham Court Road and Oxford Street.

Along the Fleet valley there have been famed springs, thrown out from the gravel by the London Clay, and which have given their names to the thickly-housed districts that were the means of their destruction ("Clerkenwell," "Bagnigge Wells," and "Coldbath Fields"), whilst "Holborn" (Old bourne) is suggestive of the brook itself, the "Fleet Ditch" of some years ago. In other parts of London we find the names "Walbrook" and "Holywell."

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* Morris, in Mag. Nat. Hist. 2d ser. vol. ii. p. 540.

† Journ. Geol. Soc. vol. xi. p. 107.

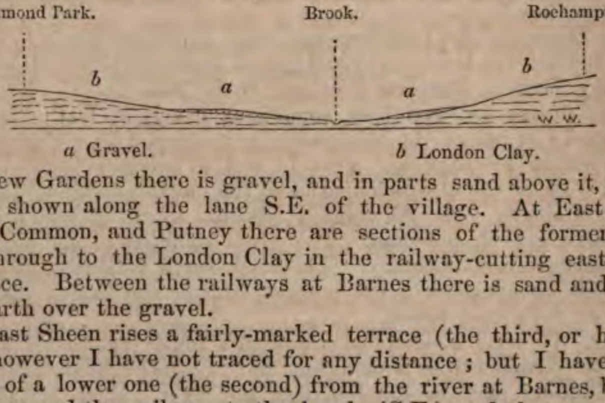
It is from the gravel that the many shallow wells of London get their water, once famous for its wholesomeness and purity ; but now, though clear and sparkling, more noted for the large amount of hurtful organic matter from graveyards, &c. that it holds in solution.

G.—On the Surrey Side of the Thames.

The flat of Ham and Petersham is gravel, and the boundary seems to be almost exactly the same as that of Richmond Park, within which the London Clay rises up sharply to some height above the flat. Some slight signs of low terraces may be seen at the northern part of the tract. At Ham Common there is at one part a little brick-earth, at another a little sand, and at Petersham much of the latter above the gravel ; whilst near the river there is chiefly gravel only.

From the higher part of Richmond the London Clay slopes right down to the river, but a little south of the bridge gravel again comes on, and seems to spread over all the lower part of the town, whence the boundary-line runs eastward to Wandsworth. The only change from the easterly course is south of East Sheen, where the gravel has once run some way up the brook-valley, although the brook has since worn its way through to the London Clay down to within a quarter of a mile of the high road, leaving a spur of gravel on either side, beyond which the London Clay hills rise up, as shown in the section, fig. 14 (along a line a mile and a half long, and nearly E. and W. ; the vertical scale exaggerated).

Figure 14.—*Section from the Northern Part of Roehampton to Richmond Park* (*south of Sheen Common*).



In Kew Gardens there is gravel, and in parts sand above it, and the latter is shown along the lane S.E. of the village. At East Sheen, Barnes Common, and Putney there are sections of the former, which is cut through to the London Clay in the railway-cutting east of the last place. Between the railways at Barnes there is sand and a little brick-earth over the gravel.

At East Sheen rises a fairly-marked terrace (the third, or highest), which however I have not traced for any distance ; but I have traced the rise of a lower one (the second) from the river at Barnes, between the village and the railway, to the brook (S.E.), and thence eastward, on the southern side of the brook, to the river at Putney. The lowest terrace therefore here takes up the space in the bend of the river, as on the other side in the bend next to the west (see p. 87).

The part of the Wandle Valley that is mapped in this sheet of the Geological Survey Map seems to be quite free from gravel on the western, whilst there is much on the other side. At the southern edge, east of and touching the alluvium, is a small triangular flat of London

Clay, free from gravel, the northern part of an outcropping patch that spreads some way to the south (Sheet 8). East and north of it the gravel comes on, rising slightly, and forming a band gradually narrowing northwards from three-quarters to less than a quarter of a mile, and bounded on the east by a strip of London Clay, which again rises a little and narrows northwards from half a mile to nothing, or next to nothing, at Wandsworth; a higher terrace of gravel coming on above that formation, and widening northwards from less than half a mile between Tooting and Streatham to a mile at Wandsworth Common, at which last place it forms the highest ground. This gravel is separated from that of Clapham Common, which belongs to the same terrace, by the valley of the little brook that flows into the Thames at Battersea, which is cut through to the London Clay as far north as the railway. The effects of the denudation of this neighbourhood are remarkable, though on a small scale. The railway-cuttings through Wandsworth Common show both the gravel and the underlying clay; the junction is very uneven and irregular in that of the Crystal Palace line, so much so indeed that the clay is often almost at the surface, though a few yards off it is covered by many feet of gravel. The northern end of this high terrace is very well marked, and forms the rising ground from the south of Wandsworth railway-station north-eastwards across the railway to the junction with the other line. It is not indeed impossible that a very narrow band of the London Clay may crop out along the flank of this low hill, and make the gravel above an outlier; but it would not have been safe to map it so. In a hole dug 50 or 60 yards south of the railway, on the road to York Place, I saw, in April 1861, about 20 feet of buff sand, with here and there a few small flints and pebbles, and as this is a little way up the slope of the hill it goes against the likelihood of the London Clay coming to the surface.

The works of the "Southern High-level Sewer" were of use in settling the N.E. boundary of the Clapham gravel; for whilst at "the Plough," and thence for some way towards Stockwell, gravel was found, further in that direction, near the fourth milestone (from London Bridge ?) the London Clay was found at the surface; still further, and bearing to the right, at Stockwell Green the trial-bore showed a thickness of more than 12 feet of made ground and gravel over the clay, proving that a lower terrace has there come on. The rise of the high terrace at Clapham is well marked, as at Wandsworth Common, and runs a little north of the road from Battersea Rise to the northern part of Clapham, and along this line there may again be a narrow outcrop of London Clay along the flank of the hill near the last place, east of which there are pits, close by the road, in sandy gravel, bedded and false-bedded; the like being also shown in the cuttings of the London Chatham and Dover Railway.

Mr. Prestwich, in his valuable little work, "The Ground Beneath Us,"* to which I would refer the reader for a general account both of the Gravels and the older Tertiary beds around London, classes the gravel of Clapham and Wandsworth Commons as "high-level." I have said before (p. 68) that I use that term in a different sense, and would rather call this "terrace-gravel." The section given by Mr. Prestwich (fig. 17, p. 30 of his pamphlet) exaggerates the vertical distance between the gravel in the bottom of the Wandle Valley and that on Wandsworth Common, which in reality is not great; indeed I have reason, as before stated, to think that the two beds join to the north.

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* Van Voorst, London, 1857.

I do not think with Mr. Prestwich that "the gravels on Clapham, "Wandsworth, and Wimbledon Commons are . . . . . on the same plane" (p. 31); the first two are, without doubt; but the last is higher, and may perhaps belong to the "high-level;" though I do not think it impossible that it may be another and still higher terrace of the "low-level."

The lower terrace of Battersea, &c. spreads up to the base of the one just described, and thence eastwards, the latter being absent, comes next to the London Clay, the boundary of the gravel running S.E. to the foot of Herne Hill, and thence along the base of the line of hill to Camberwell. I cannot say that all the space between this line and the river belongs to one terrace; indeed, Battersea Park seems to form a still lower one, and there are signs of the same in the thickly-built districts north of Camberwell. South and east of Battersea there is much brick-earth, which is worked. Along the course of the great sewer between North Brixton and Camberwell much gravel was found, and much water also, 20 feet of gravel and sand having been dug through in places without touching the London Clay.

Islands of Gravel.

Besides the tracts above described, over which the gravel is at the surface, it must be remembered that beneath the alluvium of the river it is also present. Moreover, it is not uncommon to find masses of gravel cropping out from beneath, and surrounded on all sides by the alluvium of the river. These may be called "islands." I do not know of any below Windsor. In the valley of the Loddon there are two, the one just west of Whistley Mill, the other a little to the south. There is a small one about three-quarters of a mile south of Shiplake, and another in Wargrave Marsh. Others occur on the west of Hambledon Lock, at Medmenham Abbey, at Low Grounds (S.W. of Great Marlow), just east of Marlow Mills, at Cookham and at Taplow Mills. The long flat of the lowest terrace from Whitbrook Common (south of Cookham) to Bray Mead may perhaps be an island; it is at any rate all but separated from the rest of the gravel, on the west, by a strip of alluvium.

Valley of the Lea.

The western boundary of the gravel of this river runs within the eastern edge of our district from the north of Enfield for nearly five miles to the south. The line is in great part doubtful, but from Enfield to Clay Hill follows that of the New River, on its west. There are pits at Enfield, and again near Millfield House, where a thickness of 10 feet of gravel is shown.

As before noted, the gravel just to the west may perhaps be a higher terrace of this (see p. 71).

CHAPTER XI.—POST-PLIOCENE SERIES (*continued*).

VALLEY DRIFT (*continued*).

I will now notice those masses of valley brick-earth and gravel that are not shown on the map, except by the engraved word "gravel."

Over the higher ground west of the Loddon there is a thick wide-spread sheet of gravel, which has been found in wells at Woodley Green and is shown in the railway-cutting on the north, but has not been mapped for the reason given at p. 73, although I believe it is a high terrace of the valley-beds.

On the top of the steep chalk-cliff on the southern side of the Thames between Cook Marsh and Winter Hill Farm there is gravel, the remains most likely of a very high terrace, as the Chalk and the Tertiary beds rise up to a much higher level on the south-west, and are free from gravel, except at the tops of Bowsey and Ashley Hills, where there is some of quite a different kind (see p. 69).

Along the Loudwater Valley there is here and there a little gravel, which most likely occurs everywhere beneath the alluvium. A narrow strip perhaps runs up the bottom of the valley from where the alluvium begins to a little above West Wycombe.

The large mass north of Hitcham and Burnham I take to be an outlying part of a high terrace. At the brickyard about a quarter of a mile S.E. of Wigmore Heath there is light-coloured bedded brick-earth, many feet thick, in which *mammalian bones*, in a much perished state, have been found.

There is most likely a narrow deposit of gravel in the bottom of the Misbourn valley as high as Great Missenden, and perhaps farther north, whence to Amersham it is but slightly covered here and there by alluvium. In a pit at the eastern corner of Shardeloes Park (and opposite Mantles Green) the gravel is 12 feet thick. Below Amersham it is covered by alluvium; and the same is for the most part the case along the valley of the Chess.

In the valley of the Bulbourne at Berkhampstead there is gravel, lower down covered by alluvium. At Crouch Field, on the northern side of the stream near its junction with the Gade, is a brickyard, the pits supplying which show pipes of gravel, with here and there a little brick-earth, in the Chalk. At a higher level, towards Green End, there is a terrace of gravel, many feet thick, and at Frogmoor End, below the junction of the two streams, there is more of the same. I learn from Mr. J. Evans that a tooth of *elephant* was found in the gravel near Apsley Mill, in making the canal. The small road-cuttings near the bottom of this valley are often in gravel, which here occurs not only in the bottom, but spreads some way up the hill sides; signs of small old pits may be seen in places; and about three quarters of a mile southwards of Hunton Bridge there is one now open, between the road and the railway.

Along the valleys of the Ver and the Colne gravel is abundant; and in the latter, above the junction of the two, is a high terrace; with a pit at London Colney. Below the junction the same thing again occurs above Waterside Farm and thence S.W. to beyond Watford. A thickness of 12 feet of gravel is shown in a pit in the small side-valley above Waterside; and in the next side-valley (west of Bricket Wood Common) there are also some pits. The railway-cutting N.W. of Watford Station shows gravel, in great thickness, lying irregularly on the Chalk; the former has been much worked, for ballast, &c. and belongs to the high terrace, which is here for the most part cut off from the river-flat by denudation through to the Chalk along the banks of the stream, as may be seen at Bright Wells and thence towards Twopits, and which spreads over the low flat-topped hill S.W. of Watford. In making the railway between this last place and Rickmansworth (1862) an irregular junction of the gravel and the Chalk was shown in the cutting at the town, and also in the larger one at Bright Wells. At the eastern end of the latter the gravel is 15 feet or more in thickness, and there is often sand at its base: westward, where the cutting is shallower, it is more clayey and the Chalk rises rather higher. In the next cutting also, which is long but shallow, the Chalk is touched here and there. Just south of the toll-bar west of Watford is a large pit showing about 12 feet of irregular gravel, and there is a greater thickness of the same in the pit opposite the cemetery and nearer the town. It is noteworthy that in the Watford gravel there are very many pebbles of quartz-rock and quartz (from the "New Red Conglomerate"), often of large size.—On the other (eastern) side of the Colne there are also patches of gravel some height above the river and most likely belonging to the terrace just described. There are sections in the railway-cutting at Bushey, in the chalk-pit a little to the north (see p. 63), and at Wiggen Hall to the west. On the right side of the river below Rickmansworth the gravel seems to reach a little way up the gentle slope of the chalk-hills. On the hills N. and N.W. of that town there is much gravel, perhaps belonging to a high terrace, or partly so.

There is more or less gravel along the valley of the Brent from above Kingsbury to Perivale. For the most part it seems not to run down to the river, but, having been worn away, to form a narrow band on each side. The stream either runs over London Clay, or else it has formed a stiff clay alluvium, hardly to be known from that formation; in which case of course there might be gravel below the bed of the river. In places in the channel indeed there is a wash of clay over gravel.

Alluvium.

There is no great amount of this, the modern river-deposit, in our district. A narrow flat of it runs some way up the valleys of the chalk-streams north of the Thames, and it occurs also in the valleys of the Loddon and Wandle; but strange to say along the Thames itself there is comparatively little, although east of London that river has formed broad alluvial flats. The only notable spread of alluvium is the famous Runney Mead, north of Egham, and that for its historical association and not its size.

The alluvium of this district consists of silt, or mud, and here and there a little peat or peaty earth, deposited by the rivers over the gravel in the bottoms of the valleys, and it often contains shells of species now living in the streams.

The alluvial tract of Ruscomb Lake, in the S.W. corner of the map, has been in great part laid bare by drainage. At its western end a freshly cut ditch showed me alluvial clay and sand; the former brown, blue, and black (peaty), with a little blue phosphate of iron; the latter brown, buff, green-grey, and dark green.

Westminster is built on alluvium, and was once an island (Thorney Island); but the boundary between the alluvium and the gravel is not well marked.

There is also a border of alluvium on the Surrey side of the Thames at London, and in the library of the Geological Society there is the following MS. section, at Meade Place, Lambeth:—

	ft.
Soil	3
Bluish-clay (broken bottle; and piece of coal)	2½
Dark sand, flint-pebbles, and clay	1
Fox-coloured sand, flint-pebbles, and gravel	1
Bluish clay, with flint-pebbles, and blue phosphate of iron	2
Pebbles cemented together by iron and clay	

Mr. C. Evans has described some sections that were shown in the excavations for the arches of the new Charing Cross Railway.* He says, "To the east of the Blackfriars Road, at a distance of about a "quarter of a mile from the present bank of the river, these excavations "have passed through various strata, the most constant of which was "a bed of sandy clay with vegetable matter and fragments of unrolled "flints. Near the bottom of most of the trenches beds of loam and "clay were met with containing wood, freshwater and land shells, and "insect remains. Mammalian bones have also been found low down "in the excavations." The sandy low-level gravel was found below. The details of the deepest sections, at William Street, were as follows, according to Mr. Evans ;—

		ft.
Made earth		about 7
Alluvium, about 19 ft.	Bluish clay, with vegetable matter and freshwater shells	„ 6
	Earthy peat	„ 5
	„ „ with patches of sand and clay, many shells, and large blocks of wood	„ 2
	Shelly sand and clay, with patches of peat	„ 1
	Earthy peat, with patches of shelly sand and of light buff clay	„ 1
	Peat	„ 4
Gravel and sand.		

The first and last beds of peat "are of very local occurrence, and do "not extend as far as the next parallel street to the east. The shell-"beds extend rather farther, but appear to thin out to the east," for at the third street there was nothing but four feet of made earth and a foot of yellow clay above the gravel. A shelly clay was also found "at the "excavations of the same railway in the Waterloo Road," and "at "some drainage works in the road leading to Southwark Bridge." Mr. Evans gives a list of the shells that were found in these cuttings ; all of course are common living species of the country, and belong to the freshwater genera, *Ancylus*, *Bithinia*, *Limnea*, *Neritina*, *Planorbis*, *Physa*, *Valvata*, and *Cyclas*, *Pisidium* and *Unio* (or *Anodon*) ; the amphibious genus *Succinea ;* and the land genera *Carychium*, *Clausilia*, *Helix*, *Pupa*, and *Zua*. Besides these the remains of *Goat*, *Boar*, and *Deer* were found, and also nuts, wood and seed-vessels, and wing-cases of *beetles*.

CHAPTER XII.

FORM OF THE GROUND.

Having now described all the beds that are found in the district, I will note, in a few words, the effects that they have on the surface of the ground, a surface formed of course by denudation.

The Gault gives rise to a clay-country, above which the Upper Greensand rises slightly and forms a more or less flat or gently-sloping terrace at the base of the chalk escarpment. This last is of small extent in our district (from the hills above Henton to Combe Hill, Wendover) but it forms the boldest and largest hills, the tops of which are the highest ground. The "shape of the ground" at the N.W. corner of the district will be better understood by looking at fig. 15, in which, the horizontal and vertical scales being the same, there is no exaggeration of the slopes of the hills. I must state, however, that I

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* Proceedings of the Geologists' Association, vol. i. p. 264 (1862–63).

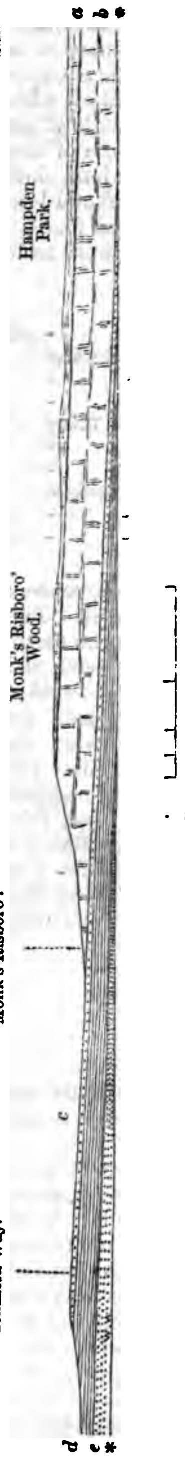

Fig. 15.—*Section from the Gault W. of Meadle to the Upper Chalk S.W. of Hampden Church.*

Scale : 2 inches to a mile.

* * Sea-level (approximate). *a* Upper Chalk. *b* Lower Chalk. *c* Upper Greensand. *d* Gault. *e* Probable Lower Greensand.

had no good authority for the heights above the sea-level; but I believe them to be very near the truth. The slope of the chalk escarpment has perhaps been made too gradual; it is often sharper.

From the escarpment the level of the chalk-district falls slowly south-eastward, higher beds of the Upper Chalk coming on without forming any feature, and though the country has the usual character of rounded hills and long branching valleys, it shows hardly any of the bare, dry "downs" generally looked upon as the most marked feature of this formation. This is owing to the higher parts of the Chalk not being bare, but covered by a clay-deposit (see p. 63), forming a soil on which trees flourish, and giving rise, therefore, to a thickly wooded country, instead of an open turf-clad down. The chief tree is the beech, which thrives well, and is grown very largely for chair-making, the head-quarters of which trade are at High Wycombe. Towards the east the Chalk is more or less covered with gravel, and there is then less wood.

The sameness of the wide drift-covered chalk-tract is somewhat broken by the outliers of the Tertiary beds scattered over it; which for the most part form small hills rising above the level of the neighbouring Chalk; but sometimes are marked objects a long way off. Thus the Lane End and Wargrave Outliers (Nos. 2 and 37, pp. 31 and 42) can be seen many miles off, and by the practised eye would at once be known as outlying masses of Tertiary beds.

The dry valleys of the Chalk are most likely caused simply by the slow and constant wearing and dissolving away of that rock by subaërial agencies. Along their bottoms there is often a little very coarse flint-gravel, the insoluble residue of those actions.

The main mass of the Tertiary beds on the west of Windsor forms next to nothing of a physical feature, hardly causing any rise of the ground at the junction with the Chalk; but the London Clay rises up into a well-marked range of hill on the south, at Binfield, Warfield, and Winkfield. Between the Thames and the Colne the Tertiary beds are so much covered by gravel, both high-level and low-level, that they do not make any very distinct feature. East of the latter river, however, they have a well-marked escarpment, forming an almost unbroken ridge, the lower part of which

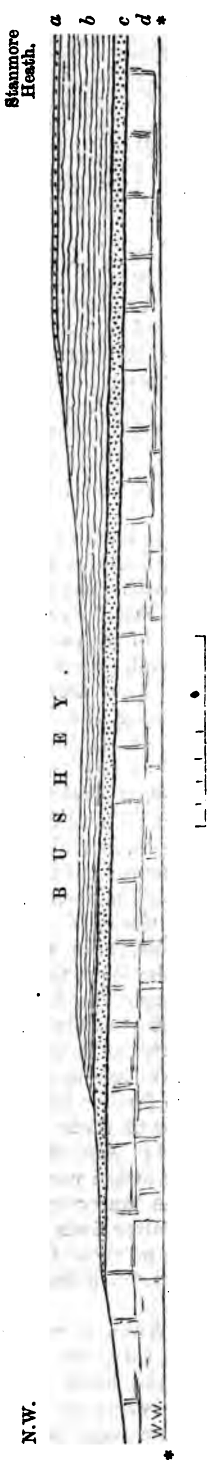

Fig. 16.—*Section from a Point about a quarter of a mile S.W. of Bushey Grove to Stanmore Heath.*

Horizontal scale, 3 inches to a mile; vertical scale, twice as large (880 feet to an inch).
* * Sea-level (approximate). *a* Pebble-gravel. *b* London Clay. *c* Reading Beds. *d* Chalk.

consists of the Chalk, the middle part of the Reading Beds, and the upper part of the London Clay, as shown in fig. 16, which also shows the way in which the latter formation rises into a second and higher ridge (often capped with gravel) some way S.E. of the escarpment.

The large part of Middlesex, &c. in which the London Clay is at or near the surface consists of a grass-land of gently rising hills, the higher ones with a capping of gravel or Bagshot Sand, and small valleys that carry off the drainage, by the gradual wearing action of which they have most likely been formed. This formation does not give rise to a perfect flat.

The Bagshot Sand occurs only as a capping, mostly well marked, on some of the high ground of the London Clay.

The high-level drifts in great part make no feature at the surface, the exception being with the gravel, which often forms small knolls.

The valley-drifts, however, have a marked effect on the shape of the ground where they take up a large space, forming wide flats, slightly sloping upwards from the river, often broken by low terraces (see p. 74), and cut through by the side-valleys. The higher terraces, however, sometimes form knolls, like the older drift.

The alluvium, of course, forms a flat of marshy land.

VALLEYS.

The Valley of the Thames runs through the southern part of the district, from west to east.

From Reading (in Sheet 13, to the west) to Twyford its southern flank is formed by the combined escarpment of the London Clay and Reading Beds, and it seems strange that the river should not have held its easterly course in like manner along the boundary of the soft Tertiary beds to Bray. Instead of this, however, it turns at right angles northwards through the Chalk to Henley, where it cuts into the Lower Chalk (see p. 6); then takes again to its easterly direction, parallel to the outcrop of the Tertiary beds from Twyford to Bray, but still in Chalk; at Cookham turns sharply south, and enters the Tertiary district near Maidenhead, when it again takes that easterly course which it keeps thence to the Nore.

That part of the valley that is cut through the Chalk is comparatively narrow, often with sharply sloping flanks, which are mostly covered with noble woods of beech from top to bottom, as may be well seen opposite Marlow and Cookham, but sometimes form a bare cliff, as at Cook Marsh. That part of the valley, on the contrary, that is in the Tertiary district is broad, and with gently sloping sides; though near Egham and south of Richmond, where the river flows near to the bounding hills, these latter are fairly sharp. This difference in the form of the ground is clearly owing to the different nature and hardness of the formations in which the valley is cut.

On the north of this main valley there are others, formed by streams, which, rising from the Chalk, flow south-eastwards in the direction of the dip, that is in the line of greatest fall of the beds, or, in other words, the line of drainage. These valleys, therefore, are for the most part parallel. They partly cut through the great escarpment, but not wholly; and it seems likely that they have been caused by the slow wearing and dissolving action of the streams. Only two of these valleys, those of the Loudwater and Misbourn, are wholly in this district; that of the Chess has not been worn back to the escarpment, whilst those of the Bulbourne, Gade, Ver, and Colne cause gaps in the escarpment in the district to the north (Sheet 46).

Whilst the Loudwater, Misbourn, and Bulbourne rise from the Chalk near its escarpment, and flow in a fairly direct line into the Thames, the water thrown out from the Chalk and Upper Greensand to the north of their rising-points (near Princes Risborough and Wendover in our district, and near Tring in Sheet 46) flows down the lower part of the chalk-escarpment, or down that of the Upper Greensand, and over the Gault plain into the Thame, which joins the Isis near Dorchester (Sheet 13, to the west), the two rivers then forming the Thames (Tamesis; Thame-Isis); and therefore this latter water, though at first flowing in a direction almost opposite to that of the chalk-valleys, at last comes to the same spot, but by a very much longer route.

I must here draw attention to the fact that whilst N. and N.W. of London the river-valleys (with the exception of the main valley, that of the Thames, which perhaps is older and in some measure of different origin from the others) do not cut right through the chalk-escarpment, and the rivers therefore do not flow through it; on the S.W., S., and S.E. of London, where the dip is sharper, the river-valleys, on the contrary, cut right through the chalk-escarpment; thus the Wey, the Mole, the Darent, the Medway, and the Stour flow through the Chalk at Guildford, Dorking, Otford, Burham, and Wye. Is it possible that in the more northerly of these districts we see a state of things that existed ages and ages ago in the more southerly? And again, may not the valleys of the Loudwater, &c. be gradually worn farther back and deeper through the chalk-escarpment; so that the rise of their streams may gradually get nearer and nearer to that escarpment? And if this go on for ages and ages yet to come, will not those valleys at last work their way back quite through the chalk-ridge, so that the water that now flows away from the hills, and then in a roundabout course finds its way into the Thames, will join that of the chalk-streams in their far more direct flow into the same river, and the northern district will then be as the southern one is now?

The change in the course of the Loudwater at Woburn where it comes into the Tertiary district is noteworthy; it turns at a right angle and flows into the Thames; whereas one might have thought that it would have kept on in its south-easterly course along the Hedgerley and Fulmer Valley. The Misbourn, however, holds its course through the Tertiary beds, though but for a short way, until it joins the Colne. This last river, which receives all the chalk-streams but the Loudwater, flows roughly parallel to the Tertiary escarpment from the west of Hatfield Park to the south-west of Rickmansworth; its course seeming to be determined simply by that ridge. Can it be that the important physical feature of the Tertiary hills has been formed by the long slow action of the river, and the streamlets that flow into it from those hills, bearing down sediment with them, and by subaërial action generally?

DISTURBANCES.

Nearly the whole of the district must have been influenced by the general disturbance which was the cause of the slight south-easterly dip of the beds, and consequently, together with the general denudation that afterwards took place, of the successive outcropping of lower and lower beds in a north-westerly direction.

Of more local disturbances there is not much evidence. One of these occurs at Windsor, where the Chalk comes up to the surface in a somewhat sudden manner (see fig. 1, p. 13). Mr. Prestwich is inclined to refer this disturbance to "a line of flexure, running east and west, " following nearly the course of the Thames from the Nore to Deptford, " and apparently continued thence to beyond Windsor."* In London the many well-sections show that the level of the top of the Chalk varies much.

The probable faults at Lane End have been fullydescribed at p. 32-4, and that at Bennet's End at p. 40.

The inliers at Ruislip, Pinner, and Northaw (see pp. 28–30) are owing to some slight local disturbance, and after-denudation. It should be noted that those near the last two places are in a straight line with the Windsor elevation. This may perhaps be accidental, but the following remarks by Mr. Prestwich would lead one to think that it is not: " As far as the obscure character of the surface and the absence of " sections will allow me to judge, a slight disturbance in the form of a " ridge or flexure of small elevation runs north-east and south-west " through Northaw . . . where it passes thence under the hills " between Potter's Bar and Barnet, bringing up there the lower beds " of the London Clay in the tunnel on the line of the Great Northern " Railway."†

There seems to be some small elevation near Dulwich (see p. 23), and it is possible that the outcrop of the Woolwich Beds there may be ended off by a fault on the east, near Brockwell Hall.

Many of the valleys may have had their first cause in some small depression or fracture of the beds. These however would not themselves form the valleys, but simply cause water to flow, and wear out a channel, in a certain direction.

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* Water-bearing Strata around London, p. 40.

† Water-bearing Strata around London, p. 49.

APPENDIX I.

Well-Sections in the Tertiary District.

[In these sections the remarks in square brackets are my own.]

Mr. Robb's, The Hyde, Edgware Road, Middlesex.—(Supplied by Mr. Thomas, C.E.)

		ft.	in.
[London Clay] 66 ft.	Yellow clay	22	0
	Blue clay	43	0
	Rock [basement-bed]	1	2
[Reading Beds] 34½ ft.	Sand	0	8
	Red clay [plastic?]	9	0
	Shingle [pebble-bed]	2	0
	Red clay [plastic?]	12	0
	Sand	11	0
Chalk		37	0
	Total	137	10

Near the Railway Station, Barnet (from Mr. Trench's Note-book).

		ft.
London Clay 115 ft.	Yellow clay	24
	Blue clay	87
	Quick-sand and pebbles (basement-bed?)	4
Reading Beds 44 ft.	Mottled clay	16
	Silver sand	4
	Pebbles in sand	1
	Mottled clay	1
	Dark sand and pebbles	7
	Dark sand	13
	Sand and flints	2
Chalk		280
	Total	439

This well was sunk for 137 ft. from the top and then bored. Water rose to a height of 130 feet below the suaface.

At Messrs. Simpsons & Co.'s Factory, Grosvenor Road, Pimlico, (1859).—(Communicated by the Messrs. Simpson.)

The top of the Section is a foot above Trinity High-water mark.

	ft.	in.
Made Earth	7	0
Gravel and Sand	19	0

		ft.	in.
[London Clay 112 ft.]	*Septaria*	0	9
	Brown clay	12	3
	Light brown clay	21	0
	Brown clays, with beds of sand from half an inch to an inch thick—nine shown in the section—containing a little water	22	0
	Brown clay with a little sand	12	6
	Clay-stone [*Septaria?*]	0	6
	Clay with roundish clay-stones	4	6
	Brownish sandy clay with small pieces of iron-pyrites (a thin bed of sand about six inches from the bottom)	13	0
	Greenish sandy clay	2	6
	Fossil wood in large pieces	0	6
	Greenish sandy clay	2	6
	Sandy clay	2	0
	Dark clay, with thin veins of sand	6	0
	Dark clay	4	0
	Brown clay with shells and iron pyrites	3	0
	Dark clay, very tenacious, with veins of sand—three shown in the section—containing water	4	6
	Conglomerate of black pebbles [flint] and shells [Basement-bed?]	0	6
[Woolwich and Reading Beds 67½ feet.]	Shells and clay (oyster-bed)	3	0
	Shells in a compact mass	0	6
	Shells and hard clay	2	3
	Claystone	0	6
	Dark clay and shells	0	3
	Claystone	0	6
	Shells in a compact mass	0	6
	Dark clay	0	6
	Dark clay	1	0
	Plastic clay	3	0
	Plastic clay, with red veins	3	0
	Reddish plastic clay, with veins of green sand	5	0
	Mottled clay	2	0
	Brown sand with green veins	4	0
	Brown sand with a few shells	1	0
	Plastic clay	1	0
	Plastic clay	1	0
	Dark clay	1	0
	Chalk ["race"?] and clay	1	0
	Plastic clays of various colours	9	0
	Brownish clay with white stones	3	0
	Brownish clay	1	0
	Yellow plastic clay, with bluish veins and whitish stones	11	0
	[Bottom-bed] Green sand with black pebbles (flint) and dark clay	2	0
	[Bottom-bed] Green sand	5	0
	[Bottom-bed] Dark green sand with pebbles	5	6
[Thanet Sand 25½ feet.]	Dark sand [made dark by being wet?]	14	6
	Dark green sand	9	0
	Green sandy clay, with flints and signs of chalk	2	0
Chalk-with-flints		100	0
	Total	331	0

APPENDIX II.

ABSTRACT of WELL-SECTIONS that have mostly been published before.

The measurements are in feet. The publication where the details, or original account of each section may be found, is shown by the affix; (*a*) Prestwich in Journ. Geol. Soc. vol. x. pp. 94 to 96 and 139 to 153; (*b*) Swindell's "Rudimentary Treatise on Well-digging, &c." 4th edit.; (*c*) Prestwich's "Water-bearing Strata around London;" (*d*) Trans. Inst. Civ. Eng.; (*e*) Appendix I; (*f*) From Mr. Trench's Note-book (whence my late colleague got the information I do not know); (*g*) Furnished by Mr. R. Paten; (*h*) Proc. Inst. Civ. Eng.; (*i*) From Mr. Polwhele's Note-book (furnished by Mr. Prestwich?); (*k*) R. W. Mylne's "Sections of the London Strata."

—	Soil, Made ground, Brick-earth and Gravel.	London Clay.	Woolwich and Reading Beds.	Thanet Sand.	Depth to the Chalk.	In Chalk.
BERKSHIRE.						
Clewer Green, near Windsor (Wycombe Cottage) (*f*)	–	–	–	–	189	97
Old Windsor (*f*)	–	–	–	–	222	9
Windsor Brewery (*i*)	–	–	–	–	0	160
„ Castle (*i*)	12	–	–	–	12	148
(1) „ Park (George's Cottage) (*f*)	56?	314	26	–	–	–
BUCKINGHAMSHIRE.						
Eton Union (*f*)	52		55?	–	107	24
Fulmer House, between Beaconsfield and Uxbridge (*f*)	14½	–	33¼	–	47¾	30?
Langley House, between Colnbrook and Upton (*f*)	–	–	–	–	124	–
Slough (Mr. Brown's) (*f*)	27	31?	36	–	94	17½
Upton Park (Mr. Bedborough's) (*f*)	–	–	–	–	107? (or more?)	–
HERTFORDSHIRE.						
(2) Near Barnet Railway-station (*e*)	–	115	44	–		280
MIDDLESEX.						
(3) Brentford (*d*, vol. i.)	25	20	–	–	–	–
„ Booth's distillery (*h*, vol. ix. diagram p. 168)	–	–	–	–	315	100
Castlebear Hill, near Ealing (*a*)	–	300	60	–	360	–
(4) Dawley, near Hayes (Countess de Salla's) (*f*)	14	134	87?	–	235?	50
Greenford, near Harrow (*f*)	–	–	–	–	150	–
Hanwell Lunatic Asylum (*a*)	21	194	75	–	290	30
Harrow Railway-station (*g*)	4	40	28	–	72	91
(5) Hayes, The Adam and Eve (*f*)	–	–	–	–	200	42
Hyde, The (*e*)	–	66	34½	–	100½	37
(6) Isleworth (*a*)	24	216	87	–	–	–

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(1) The Chalk not reached at this depth, 396 feet, but sand found.

(2) Water rose to a height of 130 feet below the surface of the ground.

(3) Boring left off, still in clay.

(4) Water rose to a height of 27 feet below the surface.

(5) „ „ 10 „ „

(6) The Chalk not reached at this depth, 327 feet.

—	Soil, Made ground, Brick-earth and Gravel.	London Clay.	Woolwich and Reading Beds.	Thanet Sand.	Depth to the Chalk.	In Chalk.
*London and Suburbs.**						
Albany Street, Grimble & Co. (*k*)	–	100	82		182	125
Apothecaries Hall, Blackfriars (*a*)	12	114	48	44	218	76
Bank of England (*a*)	26	111	58½	39	234½	100
Berkeley Square (*k*)	–	–	–	–	224	92
Black Horse Yard (Aldersgate St. ?) (*k*)	–	–	–	–	182	75
Broad Street (City) Excise Office (Gresham House) (*k*)	–	–	–	–	250	249
(7) Camden Railway-station, near Chalk Farm, (*b*, p. 70, & *h*, vol. vii. p. 11 ; *k* gives London Clay, 170 feet, Woolwich Beds and Thanet Sand? about 70 feet ; to Chalk 240 feet)	18	180?	36?	–	234	166
Camden Town, Pickford's (*k*)	–	145	70		215	82
„ Chance's (*k*)	–	140	70		210	90
Chiswick, Griffin Brewery (*a*)	40	140	90	29	299	46
Clerkenwell, Nicholson's Distillery (*c*, p. 67)	–	–	–	–	140	20
Colosseum, Regent's Park, (*k* ; *h*, vol. ix. diagram, p. 168, gives the depth to the Chalk as 196 feet)	96		75		171	79
Combe & Delafield's Brewery, Castle Street, Long Acre (*k*)	15	85	120		220	302
Covent Garden (*k*)	25	135	100		260	98
Farringdon Street and Fetter Lane, between (*k*)	–	–	–	–	190	32
Ditto ditto (*k*)	–	–	–	–	192	–
Finsbury (*a*)	–	–	–	–	170?	–
„ Whitbread's Brewery (*k*)	–	–	–	–	190	–
Fishmongers' Hall, London Bridge (*a*)	48	129?	60?		237?	–
Great Pulteney Street, Broadwood's (*k*)	–	–	–	–	204	25
Hammersmith, Bridge Road (*k*)	–	–	–	–	305	35
„ (*k*)	–	–	–	–	283	58
Hampstead, Lower Heath (*a*, & *b*, p. 77)	–	289	89		378	72
„ Road, three wells (*h*, vol. ix. diagram, p. 168)	–	–	–	–	145 to 150	–
Hampstead Road Reservoir (*d*, vol. iii. p. 240)	23	59	39½	24½	146	87
Haverstock Hill, Orphan School (*k*)	–	224	90		314	–
Holloway, City Prison (*a*)	–	135	69	13	217	102
(8) Hornsey, The Priory (*a*)	2	140	83		225	–
Islington Green, Webb & Co.'s (*k*)	–	–	–	–	175	45
Kensington Workhouse (*a* ; *k*, gives 278 feet as the depth to, and 92 feet in, the Chalk)	11	179	80		270	100

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* So far only as shown in Sheet 7 of the Geological Survey Map. The well-sections in the eastern part of London will I trust be noticed in a future Memoir.

(7) Water rose to a height of 150 feet below the surface.

(8) „ „ 70 „ „

	Soil, Made ground, Brick-earth and Gravel.	London Clay.	Woolwich and Reading Beds.	Thanet Sand.	Depth to the Chalk.	In Chalk.
Kensington (*k*)	–	–	–	–	270	–
„ (*k*)	–	–	–	–	286	135
(9) Kentish Town Waterworks, (see p.)	–	236	61½	27	324½	586
(10) Kilburn, Messrs. Verey's (*b*, p. 74)	–	235	45	–	–	–
Lombard Street, St. Mary's Woolnoth (*a* & *k*)	164		53	36	253	29
Meux's Brewery, Tottenham Court Road, (*k*,— *c*, p. 67 gives 170 feet as the depth to the Chalk, and *h*, vol. ix. diagram, p. 168, gives 156 & 256 feet as the depth in the Chalk)	19	65	76		160	265
Millbank, Seager's Distillery (*a* & *f*; *k* gives the figures 230 & 70 ; and the same as the depth to the Chalk in two other neighbouring wells)	–	–	–	–	198?	102?
Notting Dale, near Notting Hill (*a*)	17	154	73		244	12
Orange Street, near the National Gallery (*h*, vol. xix. p. 22 ; *k* gives different figures)	30	145	40	35½	250	50
Park Lane (*h*, vol. ix. diagram, p. 168)	–	–	–	–	195	–
Parker Street (?), Drury Lane (Hansard's) (*k*)	–	–	–	–	200	45
Pentonville, Model Prison (*b*, p. 106)	17	113	54½	35	219½	151
Pimlico (*h*, vol. ix. diagram, p. 168)	–	–	–	–	270	118
„ Messrs. Simpson's Factory, Grosvenor Road (*e*)	26	112	67½	25½	231	100
Regent's Park, Zoological Gardens (*k* ; *c*, p. 67, gives the figures 220 feet to the Chalk, and 7 feet in the Chalk ; *h*, vol. ix. diagram, p. 168, gives 196 feet as the depth to the Chalk)	–	155	69		224	50
Reid's Brewery, Liquorpond Street (*c*, p. 235)	–	–	–	–	136	123
Smithfield (*k*)	–	–	–	–	216	50
St. Bartholomew's Hospital (*k*)	–	–	–	–	220	30
St. Luke's, Old Street (*h*, vol. ix. diagram, p. 168 ; *k* gives 160 feet)	–	–	–	–	150	–
Trafalgar Square, in front of the National Gallery (*a* ; *k* gives different figures)	23	142	41	42	248	147
Truman & Hanbury's Brewery (*h*, vol. ii. 1842, p. 192)	–	–	–	–	nearly 200	200
Westbourne Estate Waterworks (*a*)	–	217	62	18	297	15
Westminster, Elliott's Brewery (*a*)	32	140	67½	31½	271	127
„ Thorne's Brewery (*a*)	27½	100	66½	36	230	70
White Lion Street (*h*, vol. ix. diagram, p. 168)	–	–	–	–	201	–
(11) Northolt, Hare & Hounds, near Harrow (*f*)	–	–	–	–	180	60

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(9) Sunk through the Chalk and 391½ feet below ; but unsuccessful at that depth.
(10) Not sunk deeper ?
(11) Water rose to a height of 4 feet below the surface.

—	Soil, Made ground, Brick-earth and Gravel.	London Clay.	Woolwich and Reading Beds.	Thanet Sand.	Depth to the Chalk.	In Chalk.
(12) Norwood, near Hanwell (*c*, p. 67)	–	–	–	–	325	89
Pinner (Shaft) (*a*) - - - -	–	14	39	–	53	–
Railway-station (*g*) - - -	3½	29	27½	–	60	80
„ Hill Farm(*f*) - - - -	–	–	–	–	97	–
(13) Ruislip, near the George (*f*) -	–	19	56¾	–	75¾	30
Sudbury Railway-station (*g*) - -	2	68	50	–	120	80
(14) Twyford, near Ealing (*a*) - -	–	211	41	–	–	–
(15) Uxbridge, Hillingdon end of the town (*f*) - - - - - -	18	47?	44?	–	109	30
(16) Uxbridge, near the King's Arms(*f*)	16?	54?	38?	–	108	–
(17) „ Market-place (*f*) - -	16	51?	39?	–	104	28
(18) „ Union (*f*) - - -	12	168		–	180	38 or more
West Drayton Vitriol-works (*f*) -	15	60	58½	–	133½	45½
Winchmore Hill (*a*) - - - -	–	186	44	–	230	–
SURREY.						
(19) Balham Hill, near Clapham Common (*a*) - - - - -	15	239	53	40	–	–
Bethlehem Hospital (*k*) - - -	26	95	70		191	20
Camberwell, near Church Street (*k*) -	–	–	–	–	105	–
Dulwich, Champion Hill (*k*) - -	–	–	–	–	210	298
(20) Garret Copper-mills, near Wandsworth (*a*) - - - -	9	71½	62½?	–	–	–
Lambeth, Belvedere Road, Goding's Brewery (*k*; *h*, vol. ix. diagram, p. 168, gives 180 feet as the depth to the Chalk) - - - - - -	35	100	115		250	80
(21) Lambeth, York Mead (*a*) - -	30	141	40	–	–	–
Mortlake Brewery (*a*) - - -	10	199	58	–	267	3
„ within 100 feet of the Thames (Proc. Geol. Soc. vol. ii. p. 450) -	20	240	55	–	315	50
Southwark, Barclay's Brewery (*a*) -	27½	77½	62	36	203	over 100
„ Messrs. Pott's (*h*, vol. ix. diagram p. 168) - - - -	–	–	–	–	160	–
S. W. Railway, Waterloo (*k*) - -	165		70 (not sunk through.)		–	–
Walworth? near Kennington Street (*k*)	22	42	83		147	–
Wandsworth (near), Surrey County Lunatic Asylum (*a*) - - -	–	231	60	over 40	over 330	–

(12) Unsuccessful at this depth.
(13) Water rose to the surface.
(14) The Reading Beds not passed through.
(15 & 16) Water rose to a height of 19 feet below the surface.
(17) „ „ 15½ „ „
(18) „ „ 29 „ „
(19) Chalk not touched (?) at this depth, 347 feet.
(20 & 21) Not sunk farther.

APPENDIX III.

ON the LIKELIHOOD of there being an UNDERGROUND RIDGE of OLDER ROCKS along the VALLEY of the THAMES.

In May 1855 Mr. Godwin-Austen read a paper before the Geological Society, in which, from a careful study of the geological phenomena of Belgium and the West of England, he inferred that the axis of the Ardennes in the former country was the same as that of our Mendip Hills, and that these two outcropping parts of a long line of elevation of old rocks were connected by an underground ridge of the same, hidden by the mass of overlying and unconformable secondary rocks.

To use Mr. Godwin-Austen's own words :* "The depression of the " Thames Valley represents, and is physically a continuation of, that " which, extending from Valenciennes by Douai, Bethune, Therouanne, " and thence to Calais, includes the great coal-trough of those countries," and he infers "that at an early time a line of disturbed surface was " produced, having a general E. and W. direction, and which, travers- " ing a portion of the area of the coal-growths, has placed all the mem- " bers of that series along its course either at or near the present surface," and that " we have strong *à priori* reasons for supposing that the course " of a band of Coal-measures coincides with, and may some day be " reached, along the line of the valley of the Thames, whilst some of " the deeper-seated coal, as well as certain overlying and limited basins, " may occur along and beneath some of the longitudinal folds of the " Wealden denudation."

Before this remarkable paper was printed the boring of the Kentish Town well (see p. 3) almost established the soundness of the author's reasoning, which was afterwards still more strongly confirmed by the boring at Harwich, in which a black slaty rock, most likely of Palæozoic age, was found below the Gault.

In describing the former of these sections Mr. Prestwich says : "The " Lower Greensand crops out with so much regularity both to the " north and south of London, and skirts the Gault so continuously, that " from a surface-examination of the ground there could be no apparent " reason for supposing that the same deposit was not continuous under- " ground and would be met with beneath London. I must confess that " I never contemplated the probability of any break in the order of

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* Journ. Geol. Soc. vol. xii. pp. 71 and 73.

" superposition ; but although it may prove that my anticipations were " wrong, still I would observe that geology had nevertheless indicated " the possibility of other conditions."*

The same gentleman in a later paper says : " The evidence which we " have now obtained from the boring at Harwich, combined with that " of the Calais boring, is corroborative, and of such weight, that I do " not hesitate to modify materially my former opinion of the continuous " range of the Lower Greensand under London, and to adopt in great " part Mr. Godwin-Austen's. . . . hypothesis . . . Before the " result of the Kentish Town well was known Mr. Godwin-Austen had " arrived at the conclusion that a tract of old rocks underlies the Wealden ; but he probably was as little prepared as I was for so remarkable " a confirmation of his hypothesis as that furnished by the well at Kentish Town, as there, not only were all the Oolitic series wanting, but " the Lower Greensand itself was absent. I fear therefore that there " is, under the central part at all events, of the London Tertiary area, " a tract or ridge of the older rocks immediately underlying the Chalk " and Gault, on different portions of which the three wells of Calais, " London, and Harwich have touched, the one on the Carboniferous " Series, the other on the New Red Sandstone, and the last on some " slate-rock."†

Although, however, the philosophical deductions of Mr. Godwin-Austen have had so unexpected a confirmation, it must not be supposed that because there is almost a certainty of there being a ridge of old rocks at some depth below the surface along part of the Valley of the Thames, and a likelihood of some of those old rocks belonging to the *Coal-measures,* therefore *coal* will be found at a workable depth in parts of the London District; for the alternations of sandstone, shale, &c. that so generally contain workable beds of coal, and are therefore known as the " Coal-Measures," are sometimes almost without that mineral.

The germ of this argument, so ably worked out by Mr. Godwin-Austen, may be found in an essay by the late Sir H. T. De la Beche in one of the earliest publications of the Geological Survey, where the following remarks occur :—" From the movement of the older rocks " many a mass of Coal-measures may be buried beneath the Oolites and " Cretaceous rocks on the east, the remains of a great sheet of these " accumulations, connecting the districts we have noticed (the Mendip " Hills, &c.) with those of Central England and of Belgium, rolled " about and partially denuded prior to the deposit of the New Red " Sandstone."‡

The following section, fig. 17, will perhaps make this underground anticlinal of old rocks more clearly understood. Of course detailed accuracy is out of the question in this small diagram ; but I have tried to show as much of the geological structure of the Tertiary and Cretaceous rocks in and near London as possible in the space : for instance, the general sharper dip on the south ; the thinning out of the Thanet Sand on the north ; the irregularity of the thickness of the Chalk ; the greater thickness of the Gault on the north, and of the Lower Greensand on the south ; &c. It should be distinctly understood that the representation of the old ridge is purely ideal and is merely meant to show the general nature of the phenomenon.

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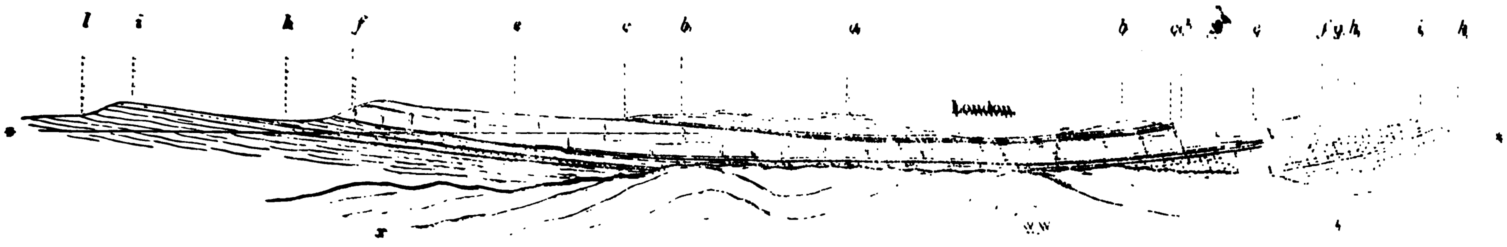
* Journ. Geol. Soc. vol. xii. p. 9.

† Journ. Geol. Soc. vol. xiv. p. 251.

‡ Memoirs of the Geological Survey, vol. i. p. 214.

Fig. 17.—*Diagram-section across the London Basin from North to South, showing the probable Ridge of Old Rocks under London, &c.*



x Ridge of Older Rocks.

* * Approximate Sea-level.

a Lower Bagshot Sand.
b London Clay.
c Woolwich and Reading Beds.
d Thanet Sand.

e Chalk with flints.
f Chalk without flints.
† *g* Upper Greensand.
† *h* Gault.

i Lower Greensand.
k Wealden Beds.
l Oolitic clays (? with patches of Wealden, Purbeck, and Portland Beds.)

† At the southern part of the section these references are too much to the right.

I may have been wrong in not showing an outcrop of Upper Greensand on the north; as it is likely that the Totternhoe Stone and Marl, which may represent that formation, extend into Herts. I have traced them as far eastwards as Barton in the Clay (on the border of Beds.), where they show no sign of thinning out.

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